Application of interventional embolization in the treatment of iatrogenic pseudoaneurysms

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Abstract. The present study aimed to investigate the clinical effectiveness and safety of endovascular embolization for the treatment of pseudoaneurysm secondary to previous abdominal and pelvic surgery or radiological percutaneous abdominal procedure. A retrospective review was performed on all patients with abdominal and pelvic pseudoaneurysm confirmed by CT angiography or digital subtraction angiography and treated with endovascular embolization. Different techniques of embolization with coils were applied and the outcomes, including clinical effectiveness and safety, were assessed. A total of 31 patients with a total of 32 pseudoaneurysms were included in the present study. Of these pseudoaneurysms, 23 were from the main trunks and branches of the gastroduodenal artery, 5 were from the splenic artery, 2 were from the common hepatic artery, 1 was from the right hepatic artery and 1 was from the right internal iliac artery. There were no serious complications observed and there was no occurrence of re-bleeding following embolization. The embolization of the pseudoaneurysms was successful in all patients. In conclusion, endovascular embolization is a safe and effective method for the treatment of secondary iatrogenic pseudoaneurysm in the abdomen and pelvis.

Introduction

Pseudoaneurysms are caused by some forms of arterial injury, which include perivascular inflammatory reactions or infections, direct vascular trauma or iatrogenic factors (1,2). With the advancement of complex surgical operations, iatrogenic pseudoaneurysms are relatively commonly encountered in clinical practice. Patients may present with sentinel bleeding or delayed hemorrhage, which may be easily overlooked (3). These pseudoaneurysms, with the lack of complete vascular wall structure, gradually increase in size and are under a growing strain with the continuous impact of blood flow, eventually resulting in burst and sudden bleeding.

The overall incidence of pseudoaneurysms following abdominal and pelvic surgery or radiological intervention is relatively low (4,5). If appropriate treatment is not undertaken in a timely fashion, pseudoaneurysm may be associated with high morbidity and mortality. Visceral artery pseudoaneurysms (VAPA) refer to pseudoaneurysms occurring in the celiac artery, superior mesenteric artery, or inferior mesenteric artery and their branches. VAPA may manifest as gastrointestinal hemorrhage (hematemesis, hematochezia) or abdominal hemorrhage (hematoma, abdominal hematoma), which is frequently evident as continuous hemorrhagic fluid from the abdominal drainage tube. A pseudoaneurysm from the pelvic internal iliac artery may also manifest as abdominal and pelvic hemorrhage or hematoma. A pseudoaneurysm may be particularly life-threatening among patients with thrombocytopenia or consumptive coagulopathy and therefore, these patients require rapid clinical evaluation and treatment (6,7).

Ultrasound with doppler and contrast-enhanced techniques are commonly used as an initial screening tool for pseudoaneurysm (8). However, CT angiography (CTA) and digital subtraction angiography (DSA), are the formal diagnostic tools for pseudoaneurysm (9). On CTA, a pseudoaneurysm may be seen as a bubble-shaped (saccular), irregular nodule budding from the lateral wall of the artery. DSA may not only clearly show the location, size and shape of the pseudoaneurysm but also its relationship with the parent artery (10,11). Pseudoaneurysms are conventionally managed by surgery, including surgical ligation, aneurysm resection and even the removal of affected organs. More recently, endovascular embolization has gradually become the preferred option of treatment instead of surgery, given that it may be rapidly applied to hemodynamically unstable patients while avoiding major surgical trauma, particularly among patients with extensive comorbidities. Several studies have also indicated high success and low recurrence rates of pseudoaneurysm treated by endovascular embolization, justifying the expansion of its applications in clinical practice (12-14).

The present study provided a retrospective review, reporting on the practice and experience of endovascular embolization at the Affiliated Hospital of North Sichuan Medical College

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(Nanchong, China). The clinical effectiveness and safety of this treatment for secondary pseudoaneurysm following abdominal and pelvic surgery or radiological percutaneous abdominal procedure were investigated.

Materials and methods

Patients. All patients with pseudoaneurysm secondary to radiological intervention or abdominal or pelvic surgery, who were then treated with endovascular embolization from January 2014 to May 2019 at the Affiliated Hospital of North Sichuan Medical College were included in the present study for a retrospective review. The present study was approved by the Ethics Committee of the Affiliated Hospital of North Sichuan Medical College (Nanchong, China). Written informed consent was obtained from all patients.

Inclusion and exclusion criteria. The inclusion criteria were as follows: i) patients presented with symptoms of bleeding after abdominal or pelvic surgery; and ii) patients without contraindications that underwent emergency arteriography or embolization therapy. The following exclusion criteria were applied: i) patients who are allergic to iodinated contrast media; ii) patients who refused interventional therapy; and iii) patients who underwent angiography without embolization.

Angiography and endovascular embolization technique. The Seldinger technique was used to puncture the femoral artery percutaneously, followed by the insertion of a 5F catheter sheath, as described in the previous study (15). Subsequently, a 5F Pig catheter, RH catheter, Yashiro catheter and Simon 1 catheter (Terumo or Cordis Co.) were inserted. Angiography of the abdominal aorta, celiac artery, common hepatic artery, splenic artery, gastroduodenal artery (GDA), superior mesenteric artery, inferior phrenic artery, inferior mesenteric artery, and the internal and external iliac artery, respectively, was performed to determine the location of bleeding and pseudoaneurysm, the size of the parent artery and the condition of collateral vessels.

A coil was routinely used for embolization at the Affiliated Hospital of North Sichuan Medical College. Various techniques for coil applications, including sac packing, isolation and sandwich, were applied using the Tower or Diamond coils (Boston VortX™-18 platinum coil or VortX™-18 Diamond platinum coil; 0.018 inches; Boston Scientific) and/or detachable coil embolization system (Interlock Fibered IDC occlusion system; 0.018 inches; Boston Scientific). The sac packing technique referred to the filling the pseudoaneurysm sac with microcoils using coaxial technology to push the distal end tip of a microcatheter (Renegade™ STC18; Boston Scientific) into the lumen and neck of the pseudoaneurysm. The isolation technique involved occluding the inflow and outflow embolization of the parent artery (exclusion embolization), while sandwich embolization involved embolizing the efferent artery, aneurysm cavity and afferent artery of the parent artery, respectively. When a pseudoaneurysm had been located on the lateral wall of the artery, the microcatheter was super-selectively placed to the sac, for which the sac packing technique was applied to maintain the patency of parent artery. If the pseudoaneurysm lumen was small and microcatheter insertion was difficult, isolation embolization was used instead of sac packing. The sandwich technique was performed for large pseudoaneurysms, or with collateral inflow and outflow arteries.

Post-embolization outcome assessment. When technical and clinical embolization therapy success was achieved, the study was stopped. The definitions and criteria for the effectiveness, technical success and clinical success of embolization were according to the Guidelines of the Society of Interventional Radiology (SIR) (16). Technical success was defined as the arrest of bleeding, disappearance of the pseudoaneurysm or occlusion of the parent artery. Clinical success referred to the absence of acute bleeding symptoms, stable hemodynamics, decrease in hemoglobin no more than 15 g/l compared with the baseline level of hemoglobin prior to embolization, no requirement for blood transfusion, no evidence of ongoing loss of blood in the abdominal drainage tube and no requirement for re-angiography or surgical intervention (17). The short-term clinical outcomes and the long-term clinical outcomes were evaluated, including abdominal pain, fever and other clinical parameters, including hemoglobin levels, signs of hemorrhage and vital signs. Follow-up CTAs or enhanced CTs were also reviewed within 6 months after embolization to evaluate the recurrence rate of the pseudoaneurysm or any evidence of ectopic embolism. The SIR criteria were also used for the classification of complications after embolization.

Results

Clinical features and angiographic findings. A total of 31 eligible patients were identified and included in the present study. Of these, 17 patients developed abdominal pseudoaneurysm following pancreaticoduodenectomy (PD), 5 after subtotal gastrectomy, 3 after a biliary operation, 5 after resection of hilar tumors and 1 patient after the radiological percutaneous drainage of an intra-abdominal collection (Table I). There were 5 females and 26 males, with the age of 58.24±8.35 years. All patients presented clinically with either symptoms and signs of gastrointestinal bleeding, abdominal hemorrhage, drainage of hemorrhagic fluid through a drainage tube or local hematoma at varying degrees.

A total of 32 pseudoaneurysms were detected among these patients, of which 23 were located at the main trunk and branches of GDA, 5 were located at the splenic artery, 2 were located at the common hepatic artery, 1 was located at the right hepatic artery and 1 was located at the right internal iliac artery. Of note, one patient was determined to have developed 2 pseudoaneurysms at the right gastroepiploic artery following PD.

On angiography, the pseudoaneurysm displayed as a cystic shadow that protruded out of the artery. It appeared as a round or irregular-shaped nodule with sharp angles on the sac and clear edges. The parent arteries were mostly spasmodic, narrowed and stiffened.

All patients had progressive deterioration in the level of hemoglobin at varying degrees. In one patient with a continuous decrease in the hemoglobin level, the initial CTA did not reveal any evidence of pseudoaneurysm but the subsequent

Table I. Clinical data of patients with iatrogenic pseudoaneurysms.

Pathogeny	Case, n (%)	Sex ratio, male/female	Location and number of aneurysms (n)
Post pancreaticoduodenectomy	17 (54.8)	13/4	Main GDA (8) Superior pancreaticoduodenal artery (5) Right gastroepiploic artery (3) Splenic artery (2)
Postoperative gastric cancer	5 (16.1)	3/2	Main GDA (2) Splenic artery (3)
Postoperative biliary surgery	3 (9.8)	2/1	Main GDA (1) Right gastroepiploic artery (1) Right hepatic artery (1)
Postoperative treatment of hilar tumors	5 (16.1)	3/2	Main GDA (3) Common hepatic artery (2)
Postoperative puncture drainage	1 (3.2)	0/1	Branches of right internal iliac artery (1)

GDA, gastroduodenal artery.

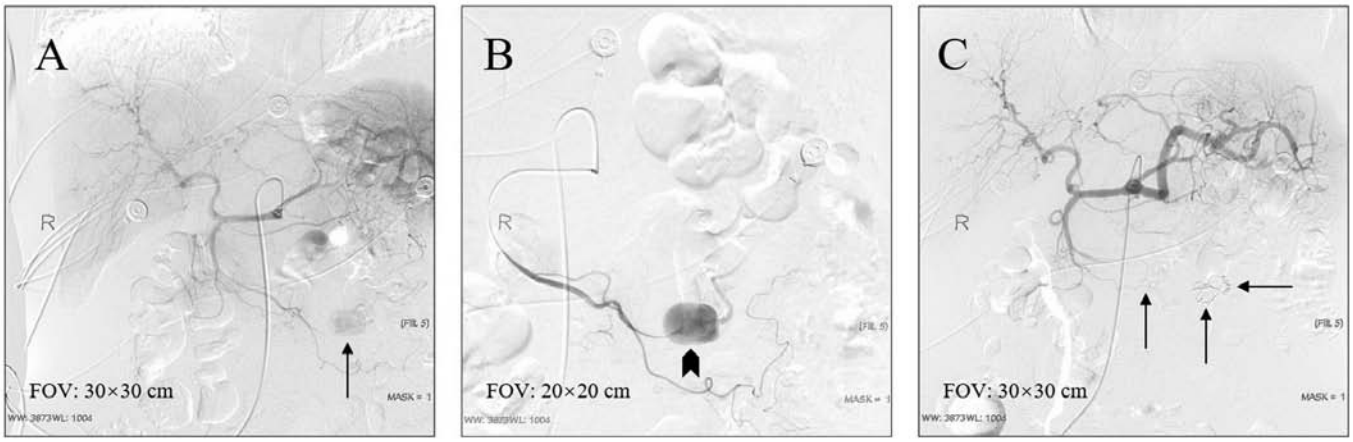

Figure 1. A 61-year-old female patient was diagnosed with pancreatic head cancer. (A) The DSA image indicated a suspicious pseudoaneurysm (arrow) of a branch of the right gastroepiploic artery; (B) this was confirmed as a saccular pseudoaneurysm (arrowhead) by local magnification angiography using coaxial catheterization technique. (C) The sandwich technique was used to embolize the sac and the inflow and outflow arteries (arrows). DSA, digital subtraction angiography; FOV, field of view.

DSA was performed given the evidence of ongoing blood loss, which revealed a pseudoaneurysm of the right hepatic artery.

Embolization techniques and outcomes. The isolation technique was most commonly performed (19/32, 59%) for embolization, followed by the sandwich technique (8/32, 25%; representative cases in Figs. 1 and 2), the sac packing technique (3/32, 9%; representative case in Fig. 3) and the proximal embolization technique (2/32, 6%). Pseudoaneurysms located at the main trunk of the GDA and pancreatoduodenal artery with no obvious communication with the superior mesenteric artery and the splenic artery, were embolized with the sac packing technique. The proximal embolization technique was used to embolize the pseudoaneurysms that were located at the distal end of the artery without collateral arteries. Of the 32 embolization procedures performed, distal migration of the coil was observed in 1 patient only (Fig. 4).

Among 5 patients with splenic artery pseudoaneurysm undergoing sandwich embolization, the subsequent imaging did not indicate any large area of splenic necrosis and these patients did not develop any significant splenic infection. However, one patient with right hepatic artery pseudoaneurysm embolized by using the sandwich embolization technique had developed transient hepatocyte damage, as evidenced by the derangement of alanine transferase and aspartate aminotransferase in the blood liver function test. All embolization procedures had a technical and clinical success rate of 100% (32/32); none of the patients required repetition of the procedure and all patients achieved complete hemostasis following embolization with no episode of re-bleeding. A total of 2 patients with pancreatic head carcinoma died of multiorgan failure secondary to severe infection 2 weeks after PD, but their deaths were not directly associated with pseudoaneurysm or endovascular embolization. There were

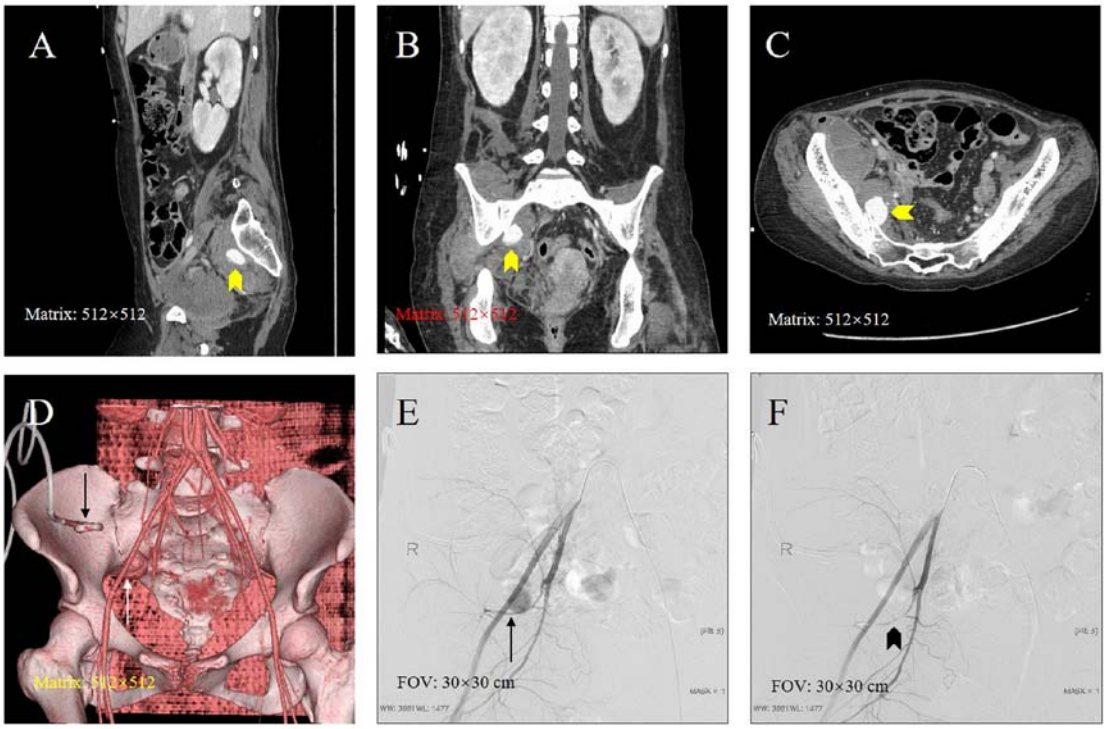

Figure 2. A 25-year-old female patient was diagnosed with a right iliac abscess. (A) Sagittal, (B) coronal and (C) axial CT indicated a pseudoaneurysm (yellow arrowhead) formed after percutaneous drainage of the abscess. (D) CT angiography displayed the size of the pseudoaneurysm and its parent artery, which was compressed and changed to an arc shape (white arrow) and a drainage tube (black arrow). (E) Angiography revealed that the parent artery was pushed inferiorly by the narrowed neck pseudoaneurysm (black arrow). (F) The sandwich technique was used to embolize the sac, inflow and outflow arteries (black arrowhead).

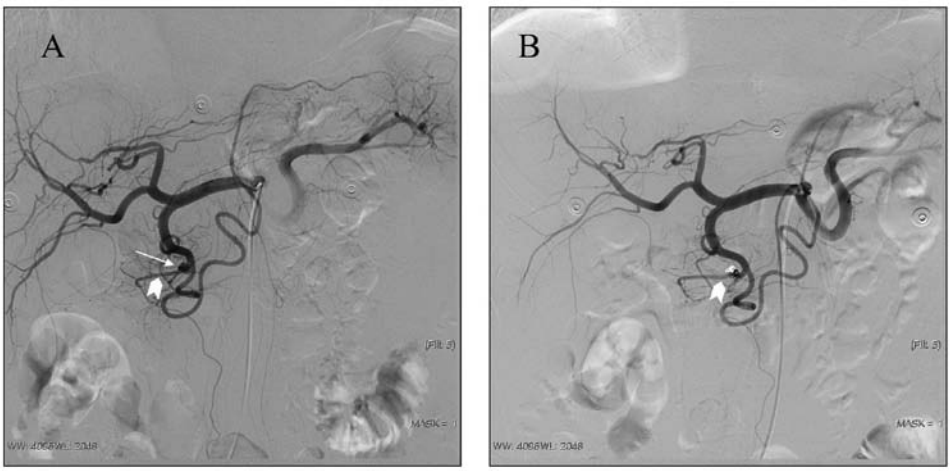

Figure 3. A 58-year-old male patient was diagnosed with choledocholithiasis. (A) Digital subtraction angiography revealed a saccular pseudoaneurysm (arrow) of the superior posterior pancreaticoduodenal artery (arrowhead) following the surgical bile duct exploration. (B) The sac packing technique was used in this case to maintain the patency of the parent artery (arrowhead).

no severe complications such as gastrointestinal ischemia and necrosis.

Discussion

Pseudoaneurysm is usually caused by the disruption of arterial wall continuity. Such a disruption may be secondary to direct injury during an abdominal procedure or surgery or various endovascular treatments, or an indirect injury from post-operative peri-vascular inflammation or infections (18-20), resulting in the formation of pseudoaneurysm. The majority of patients in the present study had received hepatobiliary/gastric surgery. Such predilection may have been due to corrosion of the arteries around the pancreas by the pancreatic juice, causing pseudoaneurysm formation and delayed bleeding (11,21). The use of electrocautery and ultrasonic scalpel in the process of clearing the lymph nodes around the artery and removing its adventitia in addition to clamping of vessels during surgery may also lead to vascular injury and subsequent pseudoaneurysm formation (22). Therefore, it is not surprising that in radical hepatobiliary/gastric surgery, the elevated incidence of surgical complications was correlated

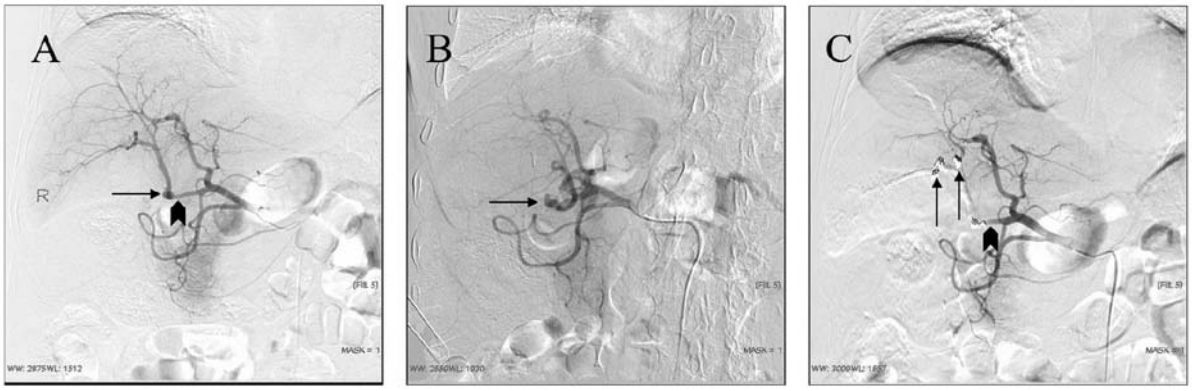

Figure 4. A 76-year-old male patient was diagnosed with choledocholithiasis. (A) Digital subtraction angiography revealed a saccular pseudoaneurysm (arrow) of the right hepatic artery (arrowhead). (B) Tangential angiography indicated an irregular shape of the pseudoaneurysm (arrow). (C) The isolation technique was used to embolize the distal and proximal side of the parent artery for isolating the pseudoaneurysm. Due to the improper size of the coil used, the distal coil (arrow) became dislodged and it escaped to the branch of the right hepatic artery. After proximal embolization of the parent artery, the pseudoaneurysm disappeared and the right hepatic artery was occluded (arrowhead).

with an increase in mortality rate associated with bleeding and pseudoaneurysm (22-25).

The risk of spontaneous rupture of a pseudoaneurysm is high and sentinel bleeding is generally regarded as a precursor of massive hemorrhage (3). Therefore, rapid and accurate diagnosis is crucial, with CTA having a sensitivity and accuracy rate of 95% (26,27). CTA is able to indicate the size and location of the aneurysm and its relationship between the parent artery and neck. One of the patients of the present study had a false-negative result on CTA, and DSA was used in this instance as a diagnostic adjunct to CTA. It also offers the possibility of therapeutic interventional therapy at the same time. During DSA, attention should be paid to the observation angle, flow rate and injection pressure of contrast agents to avoid missing small aneurysms. When necessary, magnification and multi-angle angiography should be performed (26-28).

Acute torrential hemorrhage from pseudoaneurysm may be treated by open surgical exploration/ligation or endovascular embolization (29). The following factors may affect the clinician's choice of different treatment methods: i) the time of bleeding and pseudoaneurysm; ii) comorbidities and complications, such as inflammation and infection; and iii) hemodynamics. Ligation, aneurysm resection and removal of an involved organ are the major methods of surgical treatment. Compared with the open surgical approach, endovascular therapy prevents any potential risk of serious complications caused by re-operation while minimizing further stress to impair the patient's organ function (13,17). Furthermore, the present study suggested that endovascular embolization was highly effective, that there was no further bleeding following the single intervention and no recurrence of pseudoaneurysm was observed in any of the patients.

The endovascular approach to pseudoaneurysm consists of either covered stent implantation or embolization. Endovascular graft exclusion with a covered stent may completely isolate the pseudoaneurysm immediately, prevent the rupture and bleeding of the pseudoaneurysm and reconstruct the parent artery without affecting the anatomical blood flow (30). This is suitable for pseudoaneurysm that has sentinel hemorrhage without rupture. However, a covered stent is usually not the first choice due to the risk involved and the technical difficulty of stenting in a visceral artery, in addition to the contraction of the parent artery caused by the use of vasoconstrictive drugs. Furthermore, economic and medical insurance factors are also reasons for its limited application. Therefore, endovascular embolization is widely used in clinical practice, including the Affiliated Hospital of North Sichuan Medical College, as reported in the present and previous studies (31-34). For VAPA, due to the anastomosis of digestive arteries and abundant collateral circulation, liquid embolic materials should be carefully selected to prevent the occurrence of missed embolization, and solid embolic agents generally do not cause serious ischemia and necrosis (5). The present study demonstrated that coil embolization is a safe therapy for pseudoaneurysm and no serious complications were encountered.

The selection of embolization techniques is mainly based on the location, size and the neck of the pseudoaneurysm (35). At the Affiliated Hospital of North Sichuan Medical College, if the pseudoaneurysm occurs at the main visceral artery and has a high risk of rupture, two-end embolization (isolation technique) is used, which entails embolization of the proximal and distal parent artery. In general, this technique is associated with less serious complications such as large-area organ necrosis and infection (31), and this was not observed among the patients included in the present study. According to our experience, if the GDA stump has a beak-like shape and the hepatic artery is not damaged, no further treatment is required. However, if the stump exhibits sac-like or bag-like structure, intervention is required to prevent rupture regardless, of its length. If the stump is long, the microcatheter may be inserted into the neck of the sac. In this way, embolization with microcoils does not affect the blood flow of the liver. If the stump is short or irregular, isolation embolization or stent-assisted coil embolization should be performed.

Embolization of VAPA may be technically challenging, as the visceral artery is frequently small in caliber due to the bleeding, decreased systemic blood pressure and the use of vasoconstrictive drugs. This may be improved by hemodynamic stabilization with volume replacement and discontinuation of vasoconstrictive drugs. A large-diameter

coil may then be selected for embolization, as small-diameter coils used for embolization may migrate to the efferent artery to cause rebleeding. In the present study, distal coil migration occurred in one case. The present experience conforms to the principle of 120-150, according to which the ratio of the coil diameter to the diameter of the parent artery or pseudoaneurysm should be at least 1.2-1.5, which is similar to the 'spaghetti technique' (36).

For technical considerations of VAPA embolization, it may be recommended to construct the coil with a low packing density while ensuring it is stably located in the neck of the pseudoaneurysm. According to certain scholars, a solid embolic agent such as coils may increase the risk of aneurysmal rupture due to the weak sac and damaged arterial wall, so that the sac packing technique should be selected with caution (37), while other studies recommend the sandwich technique or covered stent implantation for pseudoaneurysm secondary to mechanically injured visceral arteries to avoid the potential risk of massive bleeding during the procedure (38,39), particularly among patients with pancreatic fistula after PD. In recent years liquid embolic materials have been used for pseudoaneurysms, but the risk of undesired ectopic embolization is higher than that of a coil. The combined use of the two materials may, however, bring a higher benefit (40,41).

There were certain limitations to the present study. First, it was a retrospective, observational study with no case-control cohort for comparative analysis to determine the true effectiveness and safety of endovascular embolization over the conventional surgical approach. In addition, the sample size was relatively small due to the rarity of VAPA. Of note, the nature of the patient's medical insurance, economical status and the preference of family members are important factors that influence the choice of treatment. Additionally, the majority of patients prefer the conventional approach in China (19,31).

In conclusion, the present study indicated that endovascular embolization is a safe and effective treatment for pseudoaneurysm in the abdomen and pelvis. Several techniques of embolization were presented and discussed. The endovascular approach to VAPA should be considered as a preferred treatment option in most cases.

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Availability of data and materials

The datasets used and/or analyzed for the current study are available from the corresponding author on reasonable request.

Authors' contributions

HX and CJ made substantial contributions to the conception and design of the present study and wrote the original draft of the manuscript. JieZ, XM, JinZ, LY and YR were responsible for the data acquisition, the analysis and the interpretation. HX revised the manuscript critically for important intellectual content. All authors read and approved the final manuscript.

Ethics approval and consent to participate

The present study was approved by the Ethical Committee of the Affiliated Hospital of North Sichuan Medical College (Nanchong, China). Written informed consent was obtained from all patients.

Patient consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

References

1. Luo J, Fu X, Zhou Y, Tang H, Song G, Tang T, Liao X and Zhou X: Aortic remodeling following Sun's procedure for acute Type A aortic dissection. Med Sci Monit 23: 2143-2150, 2017.
2. Nosher JL, Chung J, Brevetti LS, Graham AM and Siegel RL: Visceral and renal artery aneurysms: A pictorial essay on endovascular therapy. Radiographics 26: 1687-1704, 2006.
3. Yekebas EF, Wolfram L, Cataldegirmen G, Habermann CR, Bogoevski D, Koenig AM, Kaifi J, Schurr PG, Bubenheim M, Nolte-Ernsting C, *et al*: Postpancreatectomy hemorrhage: Diagnosis and treatment: An analysis in 1669 consecutive pancreatic resections. Ann Surg 246: 269-280, 2007.
4. Chen X, Yuan D, Zhao J, Huang B and Yang Y: Hybrid repair for a complex infection aortic pseudoaneurysm with continued antibiotic therapy: A case report and literature review. Medicine (Baltimore) 98: e14330, 2019.
5. Madhusudhan KS, Venkatesh HA, Gamanagatti S, Garg P and Srivastava DN: Interventional radiology in the management of visceral artery pseudoaneurysms: A review of techniques and embolic materials. Korean J Radiol 17: 351-363, 2016.
6. Martins A, Goncalves A, Passos P, Cardoso M, Torres R, Almeida T and Midões A: Splenic artery pseudoaneurysm. J Gastrointest Surg 22: 1297-1298, 2018.
7. Rottoli M, Sabharwal T, Schizas AM and George ML: Bleeding pseudoaneurysm of the internal iliac artery after extended resection for advanced rectal cancer: Report of two cases. Int J Colorectal Dis 29: 1585-1586, 2014.
8. Corvino A, Catalano O, de Magistris G, Corvino F, Giurazza F, Raffaella N and Vallone G: Usefulness of doppler techniques in the diagnosis of peripheral iatrogenic pseudoaneurysms secondary to minimally invasive interventional and surgical procedures: Imaging findings and diagnostic performance study. J Ultrasound: May 20, 2020 doi: 10.1007/s40477-020-00475-6 (Epub ahead of print).
9. Li Y, Liang W, Zhang J and Peng R: Association of difference in coronary sinus diameter by computed tomographic angiography between patients in and not in stable atherosclerotic plaque(S). Med Sci Monit 24: 3265-3273, 2018.
10. Keeling AN, McGrath FP and Lee MJ: Interventional radiology in the diagnosis, management, and follow-up of pseudoaneurysms. Cardiovasc Intervent Radiol 32: 2-18, 2009.
11. Saad NE, Saad WE, Davies MG, Waldman DL, Fultz PJ and Rubens DJ: Pseudoaneurysms and the role of minimally invasive techniques in their management. Radiographics 25 (Suppl 1): S173-S189, 2005.
12. Pitton MB, Dappa E, Jungmann F, Kloeckner R, Schotten S, Wirth GM, Mittler J, Lang H, Mildenberger P, Kreitner KF, *et al*: Visceral artery aneurysms: Incidence, management, and outcome analysis in a tertiary care center over one decade. Eur Radiol 25: 2004-2014, 2015.

13. Dohan A, Eveno C, Dautry R, Guerrache Y, Camus M, Boudiaf M, Gayat E, Le Dref O, Sirol M and Soyer P: Role and effectiveness of percutaneous arterial embolization in hemodynamically unstable patients with ruptured splanchnic artery pseudoaneurysms. Cardiovasc Intervent Radiol 38: 862-870, 2015.
14. Reiter DA, Fischman AM and Shy BD: Hepatic artery pseudoaneurysm rupture: A case report and review of the literature. J Emerg Med 44: 100-103, 2013.
15. Thaut L, Weymouth W, Hunsaker B and Reschke D: Evluation of central venous access with accelerated seldinger technique versus modified seldinger technique. J Emerg Med 56: 23-28, 2019.
16. Angle JF, Siddiqi NH, Wallace MJ, Kundu S, Stokes L, Wojak JC and Cardella JF; Society of Interventional Radiology Standards of Practice Committee: Quality improvement guidelines for percutaneous transcatheter embolization: Society of Interventional Radiology Standards of Practice Committee. J Vasc Interv Radiol 21: 1479-1486, 2010.
17. Hassold N, Wolfschmidt F, Dierks A, Klein I, Bley T and Kickuth R: Effectiveness and outcome of endovascular therapy for late-onset postpancreatectomy hemorrhage using covered stents and embolization. J Vas Surg 64: 1373-1383, 2016.
18. Jabbour G, Al-Hassani A, El-Menyar A, Abdelrahman H, Peralta R, Ellabib M, Al-Jogol H, Asim M and Al-Thani H: Clinical and radiological presentations and management of blunt splenic trauma: A single tertiary hospital experience. Med Sci Monit 23: 3383-3392, 2017.
19. Pan Z, Zhang H, Li L, Jia Y and Tian R: Surgical treatment of traumatic lower limb pseudoaneurysm. Chin J Traumatol 17: 285-288, 2014.
20. Branchi V, Meyer C, Verrel F, Kania A, Bölke E, Semaan A, Koscielny A, Kalff JC and Matthaei H: Visceral artery aneurysms: Evolving interdisciplinary management and future role of the abdominal surgeon. Eur J Med Res 241: 17, 2019.
21. Gabelmann A, Gorich J and Merkle EM: Endovascular treatment of visceral artery aneurysms. J Endovasc Ther 9: 38-47, 2002.
22. Feng J, Chen YL, Dong JH, Chen MY, Cai SW and Huang ZQ: Post-pancreaticoduodenectomy hemorrhage: Risk factors, managements and outcomes. Hepatobiliary Pancreat Dis Int 13: 513-522, 2014.
23. Dumitru R, Carbunaru A, Grasu M, Toma M, Ionescu M and Dumitrascu T: Pseudoaneurysm of the splenic artery-an uncommon cause of delayed hemorrhage after pancreaticoduodenectomy. Ann Hepatobiliary Pancreat Surg 20: 204-210, 2016.
24. Gao F, Li J, Quan S, Li F, Ma D, Yao L and Zhang P: Risk factors and treatment for hemorrhage after pancreaticoduodenectomy: A case series of 423 patients. Biomed Res Int 2016: 2815693, 2016.
25. Schafer M, Heinrich S, Pfammatter T and Clavien PA: Management of delayed major visceral arterial bleeding after pancreatic surgery. HPB (Oxford) 13: 132-138, 2011.
26. Jesinger RA, Thoreson AA and Lamba R: Abdominal and pelvic aneurysms and pseudoaneurysms: Imaging review with clinical, radiologic, and treatment correlation. Radiographics 33: E71-E96, 2013.
27. Dohan A, Dautry R, Guerrache Y, Fargeaudou Y, Boudiaf M, Le Dref O, Sirol M and Soyer P: Three-dimensional MDCT angiography of splanchnic arteries: Pearls and pitfalls. Diagn Interv Imaging 96: 187-200, 2015.
28. Balderi A, Antonietti A, Ferro L, Peano E, Pedrazzini F, Fonio P and Grosso M: Endovascular treatment of visceral artery aneurysms and pseudoaneurysms: Our experience. Radiol Med 117: 815-830, 2012.
29. Vander Mijnsbrugge W, Laleman W, Van Steenbergen W, Heye S, Verslype C and Maleux G: Long-term clinical and radiological outcoome of endovascular embolization of pancreatitis-related pseudoaneurysms. Acta Radiol 58: 316-322, 2017.
30. You Y, Choi SH, Choi DW, Heo JS, Han IW, Han S, Shin SW, Park KB, Park HS, Cho SK and Han SH: Long-term clinical outcomes after endovascular management of ruptured pseudoaneurysm in patients undergoing pancreaticoduodenectomy. Ann Surg Treat Res 96: 237-249, 2019.
31. Xu H, Jing C, Zhou J, Min X, Zhao J, Yang L and Ren Y: Clinical efficacy of coil embolization in treating pseudoaneurysm post-Whipple operation. Exp Ther Med 20: 37, 2020.
32. Zhao Q, Xu H, Min X, Yang L and Ren Y: Imaging features of vertebral aneurysmal bone cyst and the clinical value of interventional embolization. Exp Ther Med 20: 3832-3836, 2020.
33. Liao X, Xu H, Liu F, Min X, Li Y, Yang L and Ren Y: Value of angioembolization in the treatment of iatrogenic renal vascular injury assisted by 3-dimensional digital subtraction angiography. Med Sci Monit 26: e927208, 2020.
34. Xu H, Min X, Li Y, Yang L and Ren Y: A comparative study of conservation, endovascular embolization therapy, and surgery for blunt renal trauma. Med Sci Monit 26: e922802, 2020.
35. Wang D, Su L, Han Y and Fan X: Embolization treatment of pseudoaneurysms originating from the external carotid artery. J Vasc Surg 61: 920-926, 2015.
36. Giurazza F, Corvino F, Cavaglià E, Silvestre M, Cangiano G, Amodio F, De Magistris G and Niola R: Emborrhoid in patients with portal hypertension and chronic hemorrhoidal bleeding: Preliminary results in five cases with a new coiling release fashion 'Spaghetti technique'. Radiol Med 125: 1008-1011, 2020.
37. Sueyoshi E, Sakamoto I, Nakashima K, Minami K and Hayashi K: Visceral and peripheral arterial pseudoaneurysms. AJR Am J Roentgenol 185: 741-749, 2005.
38. Lwin TM, Leigh N, Iskandar ME, Steele JG, Wayne MG and Cooperman AM: Rare, uncommon, and unusual complications after pancreaticoduodenal resection. Surg Clin North Am 98: 87-94, 2018.
39. Jesinger RA, Thoreson AA and Lamba R: Abdominal and pelvic aneurysms and pseudoaneurysms: Imaging review with clinical, radiologic, and treatment correlation. Radiographics 33: E71-E96, 2013.
40. Madhusudhan KS, Gamanagatti S, Garg P, Shalimar, Dash NR, Pal S, Peush S and Gupta AK: Endovascular embolization of visceral artery pseudoaneurysms using modified injection technique with N-Butyl cyanoacrylate glue. J Vasc Interv Radiol 26: 1718-1725, 2015.
41. Leyon JJ, Littlehales T, Rangarajan B, Hoey ET and Ganeshan A: Endovascular embolization: Review of currently available embolization agents. Curr Probl Diagn Radiol 43: 35-53, 2014.