Vascular Specialist International
pISSN 2288-7970 • eISSN 2288-7989
(2023) 39:1

Case Report

Endovascular Management of Hepatic Artery Pseudoaneurysms: A Case Series

Pui Lam Cheung, Yat Sing Lee, Chong Boon Tan, Hin Yue Lau, Chi Wai Siu, Chik Xing Chan, Wai Tat Chan, Cheuk Him Ho

Department of Radiology, Tuen Mun Hospital, Hong Kong, China

Although rare, hepatic artery aneurysms are associated with a high morbidity and mortality, necessitating a prompt diagnosis. A significant proportion of hepatic artery aneurysms are pseudoaneurysms, and the major risk factors of which have already been identified in previous literatures. Presentation can be variable, but diagnosis almost relies entirely on computed tomography and digital subtraction angiography. The endovascular approach has progressively become the preferred option due to its better performance when compared to the traditional surgical approach. However, formulation of an endovascular treatment plan for these lesions remains difficult as multiple factors should be considered to identify the best endovascular treatment modality. Five cases of pseudoaneurysm due to recent Whipple operation, hepatobiliary infections, and underlying malignancy are presented in this article to illustrate the effectiveness and complexity of endovascular treatment in this disease entity.

Key Words: Hepatic artery, False, Aneurysm, Endovascular procedures, Stent

Received November 7, 2022
Revised December 29, 2022
Accepted January 2, 2023
Published on February 13, 2023

Corresponding author: Pui Lam Cheung
Department of Radiology, Tuen Mun Hospital, 23 Tsing Chung Koon Road, Tuen Mun, Hong Kong, China
Tel: 852-61891932
Fax: 852-24663569
E-mail: cpl743@ha.org.hk
https://orcid.org/0000-0002-7541-4588

Cite this article; Vasc Specialist Int 2023. https://doi.org/10.5758/vsi.220053

INTRODUCTION

Hepatic artery aneurysm is the second most common visceral aneurysm and is still a rare entity; however, prompt diagnosis and treatment are necessary due to the high morbidity and mortality of this condition. Pseudoaneurysms account for half of hepatic artery aneurysms [1], of which the major risk factors include hypertension (HTN), vascular disease, pancreatitis, diabetes mellitus (DM), autoimmune disease, infection, malignancies, trauma, and iatrogenic causes [1-4].

It can be challenging to formulate an appropriate treatment for patients due to variations in the anatomy of the supplying vessels, the configuration and location of the lesions, and the underlying causes of the lesions. Surgery has been the initial treatment of choice; however, this method is now gradually being replaced by endovascular procedures as endovascular procedures are minimally invasive, have higher success rates, and demonstrate lower complication rates [5].

Here we present five cases of hepatic artery pseudoaneurysm that were diagnosed and treated with different endovascular procedures in our unit from June 2021 to June 2022. The study was approved by the Hospital Authority NTWC Cluster Research Ethics Committee (IRB no. 2022-266). The written informed consents were waived by the Board.

CASES

Generally, patients with hepatic artery pseudoaneurysms are often diagnosed by contrast-enhanced computed tomography (CT) for acute intra-abdominal bleeding or other conditions (e.g., postoperative intra-abdominal fluid col-

lection). Digital subtraction angiography (DSA) would then be arranged for confirming the CT findings and treatment planning.

The choice of endovascular treatment is decided by on-table interventional radiologists depending on the configuration of the lesions and the parent arteries. In our unit, the available options include gelfoam, coils, and *N*-butyl cyanoacrylate (NBCA) glue. However, designated stents for hepatic arteries are not available at our institution. Therefore, flow diverters and covered stents, along with their delivery equipment, used in endovascular neuro-interventions are applied in stent grafting for hepatic artery pseudoaneurysms. This is illustrated in the subsequent cases and discussion sections (Table 1).

1) Case 1

Patient 1 was an 84-year-old male with multiple comorbidities, including DM and HTN. The patient presented to our hospital with old melena, and esophagogastroduodenoscopy (EGD) showed a large volume of active haemobilia. In addition, an episode of acute cholecystitis, confirmed by ultrasonography (USG) and CT and treated with antibiotics, had occurred three months prior.

CT on the same day as EGD showed features of chronic cholecystitis with haemobilia. A ≤0.8 cm saccular pseudoaneurysm was detected over the bifurcation of the right hepatic artery, with no features of active bleeding (Fig. 1A).

Angiography and embolization were performed shortly after the CT scan. Angiography was performed with a 5-Fr Simmons 1 catheter (Merit Medical), 0.035-inch Terumo guidewire, Excelsior-1018 microcatheter (Stryker Neurovascular), and 0.014-inch Traxcess microguidewire via a 5-Fr vascular sheath in the right groin, and it confirmed the findings of a pseudoaneurysm over bifurcation of the right hepatic artery with no active contrast extravasation (Fig. 1B). Next, coil embolization of the parent artery using the sandwich technique was performed successfully without complications (Fig. 1C). Coiling began with detachable coils, as these allow for precise deployment during the procedure. Concerto Helix coils with dimensions of 5 mm×20 cm and 4 mm×10 cm were applied in this case. These were then followed by pushable coils (VortX-18 3 mm×22 cm) that allow rapid deployment. This is important in emergency conditions, as this coil type is less complicated to deploy.

The patient's condition stabilized after embolization, with no recurrence noted clinically. Further follow-up imaging could not be performed, as the patient passed away four months later due to an episode of sepsis.

Table 1. Demographics, treatment choices, angiographic outcomes, and follow-up information of 5 patients with hepatic artery pseudoaneurysm

Case	Age	Presentation	Cause	Treatment	Angiographic outcome	Follow-up CT (mo)	Clinical follow-up results
1	84	Haemobilia	Chronic cholecystitis	Coil embolization of parent artery	Success	No	Death due to sepsis 4 mo after index procedure
2	92	Haemobilia	Acute cholangitis	NBCA embolization of the lesion	Success	No	Survival during 12 mo of follow-up
3	73	Hemoperitoneum	Post Whipple operation	Flow diverter with covered stents	Success	9	No recurrence with preserved parent artery
4	76	Hemoperitoneum	Post Whipple operation	Stent-assisted coiling (1st); coil embolization (2nd); flow diverter and covered stents (3rd)	Success	7	No recurrence with preserved parent artery
5	60	Haemobilia	Neuroendocrine tumor with multiple hepatic metastasis	Coil embolization of the lesion	Success	No	Death due to malignancy 4 mo after index procedure

All the patients are males. Angiographically success is defined as complete obliteration of the pseudoaneurysm on post treatment angiogram [7].
NBCA, N-butyl cyanoacrylate; CT, computed tomography.

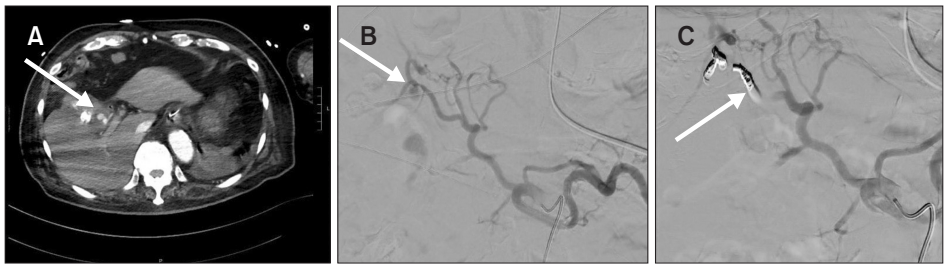

Fig. 1. Images for Case 1. (A) Computed tomography showed a ≤0.8 cm saccular pseudoaneurysm over the bifurcation of the right hepatic artery (arrow), with no features of active bleeding. (B) The pre-treatment celiac angiography showed a pseudoaneurysm, with no features of active bleeding (arrow). (C) The post-coiling celiac angiography showed complete obliteration of the right hepatic artery by using the sandwich technique (arrow).

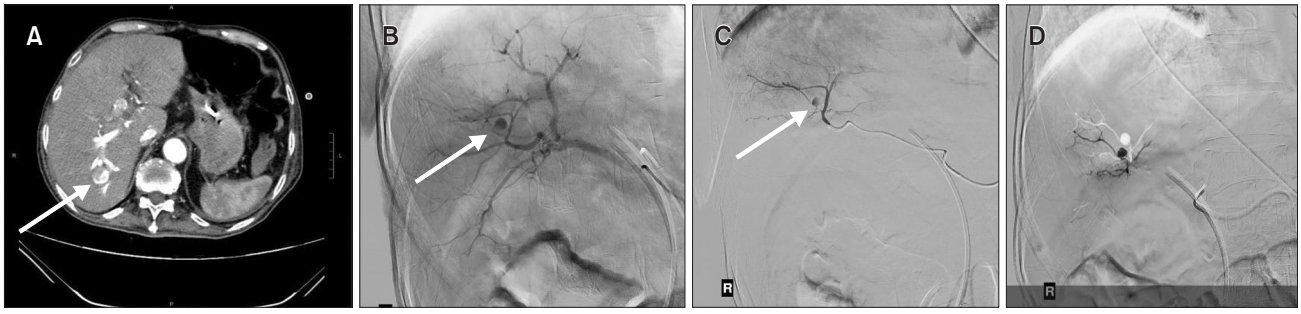

Fig. 2. Images for Case 2. (A) Computed tomography showed a ≤0.6 cm pseudoaneurysm over the posterior branch of the right hepatic artery (arrow), with surrounding abnormal contrast pooling. (B) The pre-treatment right hepatic angiography showed a pseudoaneurysm (arrow) from a branch of the right hepatic artery, with no features of active bleeding. (C) The pre-treatment segment 6 segmental angiography showed a pseudoaneurysm (arrow) arising from this artery, with no features of active bleeding. (D) The post-*N*-butyl cyanoacrylate glue embolization angiogram showed complete obliteration of the segmental artery and the pseudoaneurysm.

2) Case 2

Patient 2 was a 92-year-old male with multiple comorbidities, including DM and HTN. The patient was admitted to hospital with fever and atrial fibrillation. USG of the hepatobiliary system as part of the patient's septic workup showed features of biliary obstruction from multiple ductal stones. The patient was then treated for cholangitis with antibiotics, but a suboptimal response was obtained; therefore, endoscopic retrograde cholangiopancreatography (ERCP) was arranged, and active haemobilia was discovered incidentally.

CT performed on the same day as ERCP showed a 0.6-cm arterial enhancing outpouching from the posterior branch of the right hepatic artery with abnormal contrast pooling over segment 6/7 of the liver. This finding was suspected to be a pseudoaneurysm with rupture (Fig. 2A).

Angiography and embolization were performed shortly after CT via a 5-Fr vascular sheath as vascular access for a 4-Fr Cobra 1 catheter (Cordis Corp.) with a 0.035-inch Terumo guidewire and a 2.4-Fr Merit Maestro microcatheter (Merit Medical) with a 0.014-inch Traxcess microguidewire. An angiogram confirmed the CT findings, including the presence of a pseudoaneurysm arising from segment 6 segmental artery (Fig. 2B, C). NBCA glue embolization (16% concentration) of the artery was performed successfully, with no complications (Fig. 2D).

No more features of haemobilia could be detected clinically after the procedure, and the patient was subsequently discharged after sepsis was resolved. Follow-up imaging was pending at the time of writing this case series (approximately 12 months post-procedure).

3) Case 3

Patient 3 was a 73-year-old male with multiple comorbidities, including DM and HTN. The patient underwent Whipple operation for extrahepatic cholangiocarcinoma complicated by a postoperative pancreatic leak causing fluid collection. Antibiotic treatment was then initiated.

Three weeks after the operation, fresh blood from the tubal drains was noted along with a significant drop in he-

moglobin and unstable hemodynamics. CT revealed a large (≤3 cm) saccular pseudoaneurysm at the proximal common hepatic artery, which was soaked within the fluid (Fig. 3A). The lesion showed an irregular contour that was likely the cause of the bleeding. The distal common hepatic artery also showed irregular contours with stenosis.

An angiogram on the same day, which was performed using a 4-Fr Cobra 1 catheter and a 0.035-inch Terumo guidewire via a 6-Fr vascular sheath in the right groin, confirmed the CT findings (Fig. 3B). The portal veins remained patent. The surgeons expressed concern about the unhealing of the anastomosis from the Whipple operation after embolization. Therefore, flow diverters (Pipeline flow diverter 5 mm×25 mm, 5 mm×30 mm and 5 mm×35 mm) and then covered stents (Papyrus PK 5 mm×20 mm covered stent) were deployed to the common hepatic artery via a system composed of 071 Benchmark guiding catheter, 053 Sofia intermediate catheter, 2.7-Fr Phenom microcatheter, and Synchro 300 microguidewire through the same 6-Fr vascular sheath. A loading dose of aspirin 320 mg was administered orally before deployment of the covered stents. Successful obliteration of the pseudoaneurysm was achieved with preservation of the common hepatic artery blood flow (Fig. 3C).

The patient's condition stabilized after the procedure. The patient was scheduled to receive lifelong 80 mg aspirin daily. Follow-up CT one month, three months, and nine months after stenting showed no recurrent or residual pseudoaneurysm, with preserved common hepatic artery blood flow. No obvious complications were noted.

4) Case 4

Patient 4 was a 76-year-old male who underwent Whipple operation with hepatic wedge resection of segment 6 for pancreatic head adenocarcinoma with hepatic oligometastases. Postoperative intra-abdominal collections were developed and treated with conservative management.

Fresh blood from the patient's tubal drains was noted two weeks after the operation. CT showed a moderate volume of hemoperitoneum with a 0.7-cm saccular aneurysm originating from the left hepatic artery (Fig. 4A, B). The angiogram, which was performed with a 4-Fr Cobra 1 catheter and 0.035-inch Terumo guidewire via a 6-Fr vascular sheath in the right groin on the same day as the CT, confirmed the CT findings (Fig. 4C). Stent-assisted coiling was performed with partial embolization to avoid coil herniation into the common hepatic artery (Fig. 4D, E). This was performed via a system composed of a Neuron Max 6F 088 long sheath, a Phenom 27 microcatheter, and a Traxcess microguidewire. A 5 mm×25 mm pipeline flow diverter was first deployed as a scaffold for the deployment of the coil. Detachable coils were used in this case for precise deployment into the pseudoaneurysm sac in the presence of a flow diverter. Several Target coils were then deployed (9 mm×30 cm, 8 mm×30 cm, 7 mm×30 cm, and 7 mm×20 cm).

Another episode of fresh blood exiting the tubal drain occurred the following day. A repeat angiogram showed enlarged known pseudoaneurysm with active contrast extravasation (Fig. 4F). The stent had also migrated, with a proximal opening evident within the pseudoaneurysm sac. Coil embolization of the left hepatic artery, pseudoaneurysm sac, and origin of the left hepatic artery was performed sequentially with multiple Target coils (9 mm×30 cm, 8 mm×30 cm, 7 mm×30 cm, 6 mm×30 cm, and 5 mm×30 cm). Complete obliteration of the left hepatic artery was achieved (Fig. 4G).

A follow-up CT one month later showed regrowth of the pseudoaneurysm (Fig. 4H). An angiogram performed the next day confirmed the CT findings of pseudoaneurysm regrowth with a wide neck and involvement of the right hepatic artery (Fig. 4I). A flow diverter (Pipeline flow diverter 5 mm× 35 mm) then covered stents (Papyrus PK 5 mm×20

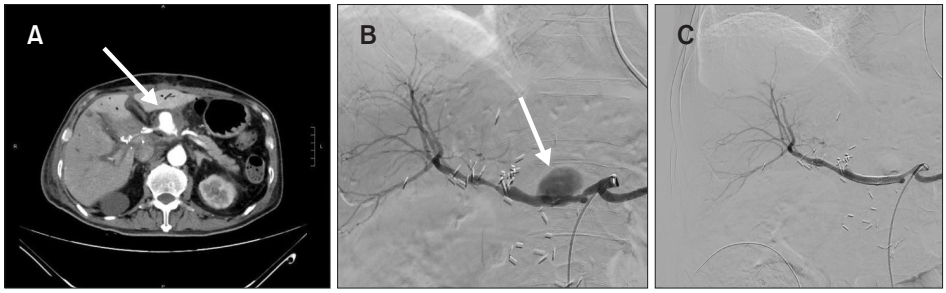

Fig. 3. Images for Case 3. (A) Computed tomography showed an ≤3 cm saccular pseudoaneurysm over the proximal common hepatic artery (arrow). (B) The pre-treatment celiac angiography showed a pseudoaneurysm over the proximal common hepatic artery, with no features of active bleeding (arrow). (C) The celiac angiography after the deployment of flow diverters and a covered stent showed complete obliteration of the pseudoaneurysm and preservation of the arterial blood flow.

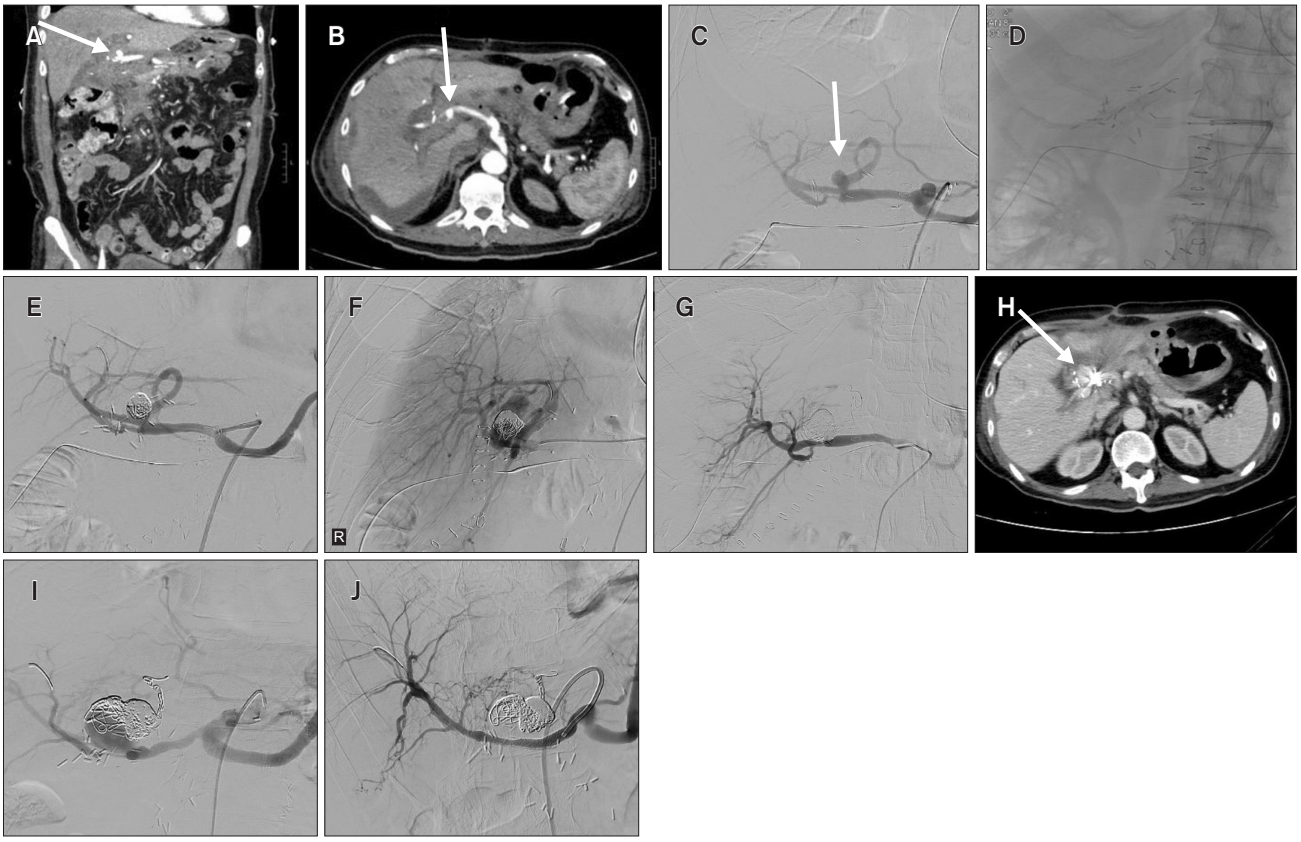

Fig. 4. Images for Case 4. (A) The coronal view on computed tomography (CT) 2 weeks after Whipple operation showed a ≤0.7 cm saccular pseudoaneurysm over the origin of the left hepatic artery (arrow). (B) The axial view of the CT also showed a ≤0.7 cm saccular pseudoaneurysm (arrow). (C) The celiac angiography confirmed the presence of a saccular aneurysm originating from the origin of the left hepatic artery (arrow). (D) Stent deployment was performed to assist the coiling of the aneurysm. (E) The celiac angiography after the stent-assisted coiling showed loose packing of the coil, which allowed for partial embolization. (F) The common hepatic angiography showed enlargement of the known pseudoaneurysm despite coiling one day prior. (G) The common hepatic angiography after coiling of the left hepatic artery and pseudoaneurysm sac showed complete obliteration of the artery and the pseudoaneurysm. (H) CT showed regrowth of the pseudoaneurysm despite previous coiling (arrow). (I) A common hepatic angiography confirmed the regrowth of the pseudoaneurysm with the involvement of the right hepatic artery. (J) The common hepatic angiography after the deployment of a flow diverter and covered stents to the right hepatic artery showed elimination of the pseudoaneurysm along with preserved right hepatic artery blood flow.

mm covered stent) were deployed via a system composed of 071 Benchmark guiding catheter, 053 Sofia intermediate catheter, 2.7-Fr Phenom microcatheter, and Synchro 300 microguidewire through the 6-Fr vascular sheath in order to preserve the right hepatic artery blood flow as requested by surgeons. This was performed to avoid healing impairment of the anastomosis from the recent Whipple's operation. A loading dose of aspirin 320 mg was administered orally before deployment of the covered stents. Complete elimination of the pseudoaneurysm with preserved right hepatic artery flow was achieved (Fig. 4J).

The patient was scheduled to receive lifelong 80 mg aspirin daily. Follow-up CT one month, three months, and 7 months after stenting showed no recurrent or residual pseudoaneurysm, with preserved right hepatic artery blood flow.

5) Case 5

Patient 5 was a 60-year-old male with a biopsy-proven metastatic neuroendocrine tumor of unknown origin, presenting with multiple liver masses and multifocal biliary tree strictures discovered by USG, CT, and ERCP during the patient's workup for anorexia and right upper quadrant abdominal pain. The patient was admitted to our hospital for hematemesis leading to unstable hemodynamics and a drop in hemoglobin level. EGD showed a large volume of blood clots inside the stomach and duodenum, with active

haemobilia.

CT was performed immediately to confirm the EGD findings. A pseudoaneurysm was detected near the common bile duct, which was suspected to have originated from the right hepatic artery (Fig. 5A).

An angiogram on the same day, which was performed using a 4-Fr S1 catheter, 0.035-inch Terumo guidewire, 1018 microcatheters, and Transend Floppy microguidewire through a 5-Fr vascular sheath, showed a large pseudoaneurysm arising from the proximal right hepatic artery (Fig. 5B). Cannulation of the distal right hepatic artery failed despite repeated attempts with different microcatheter and microguidewire combinations (2.4-Fr Merit Maestro, Pursue microcatheter, and Traxcess microguidewire), likely due to the mass effect of the multiple liver masses. Coil embolization of the pseudoaneurysm was then performed, with no retrograde filling of the pseudoaneurysm noted on the post-procedural angiogram (Fig. 5C). Target 3D coils (14 mm×50 cm, 12 mm×45 cm, 10 mm×40 cm) were first deployed into the pseudoaneurysm sac to provide a stable foundation for the further deployment of the other coils to fill up the sac, which were Axium coils (10 mm×40 cm) in this case.

The patient's hemodynamics stabilized with no further drop in hemoglobin after embolization. No further imaging was performed due to poor patient's condition, with death occurring 4 months after the procedure.

DISCUSSION

Pseudoaneurysms are distinguished from true aneurysms on the basis of their clinical and radiological features. Pseudoaneurysms are often preceded by trauma, regional inflammatory/infectious changes, malignancy, or biliary interventions [1,4], as illustrated in our cases. Cases 1-4 had a history of cholecystitis, cholangitis, or postoperative intra-abdominal abscess over the afflicted region. Cases 3-5 had malignancies with hepatobiliary/pancreatic involvement that were still active or recently operated.

Imaging of pseudoaneurysms often shows focal arterial disruption with irregular outlines in otherwise normal arteries, sometimes in conjunction with regional inflammatory changes [1]. A saccular lesion with an eccentric location or eccentric thrombosis is more likely to be a pseudoaneurysm [5].

Further, hepatic artery aneurysms, whether pseudoaneurysms or true aneurysms, have a high chance of rupture. The common presentation is usually Quinke's triad, that is, jaundice, biliary colic, and GI bleeding. Some studies report that half of the lesions rupture into the biliary tract, causing haemobilia or GI bleeding, while the other half rupture into the peritoneal space [2,3]. In our cases, three presented with haemobilia, while the remaining two presented with hemoperitoneum and bleeding into the intra-abdominal tubal drains, which is consistent with the literature.

Whether the risk of rupture is associated with lesion size remains controversial [2,5]; however the mortality rate is high once lesions rupture. Therefore, most studies advocate treating these lesions, regardless of their size, even if the patients are asymptomatic [1,5].

CT angiography is often used to detect hepatic artery aneurysms, as this method is readily available and non-invasive. CT can delineate the anatomical configuration of the lesions and regional vasculatures while excluding concomitant aneurysms or other vascular pathologies, as well as assess the potential underlying causes (e.g., regional infection or malignancies). Therefore, CT is a valuable tool for pre-procedural planning. In this case series, all patients underwent CT angiography before proceeding with further management.

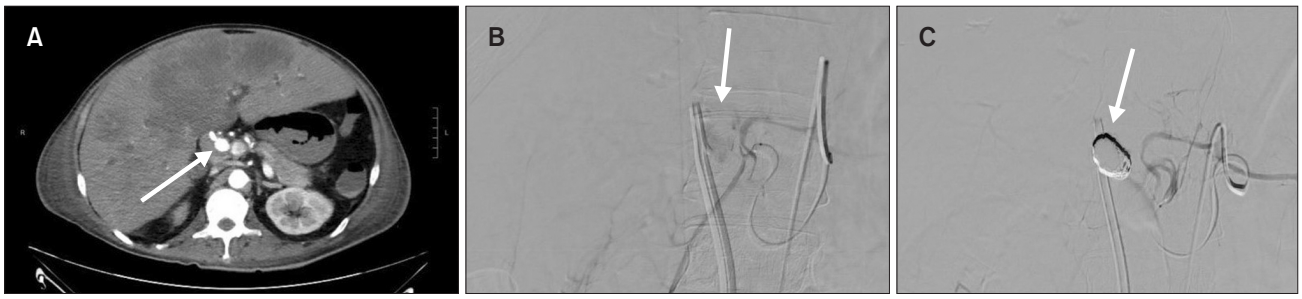

Fig. 5. Images for Case 5. (A) Computed tomography showed a pseudoaneurysm in close proximity to the common bile duct that was suspected to originate from the right hepatic artery (arrow). Multiple hypoenhancing hepatic lesions corresponding to known metastasis were also evident. (B) The pre-treatment common hepatic angiography showed a pseudoaneurysm over the proximal right hepatic artery (arrow), with no features of active bleeding. The presence of a biliary stent was also seen. (C) The common hepatic angiography after coil embolization of the pseudoaneurysm showed complete obliteration of the pseudoaneurysm (arrow).

Despite the advantages and importance of CT angiography, DSA remains the gold standard for the diagnosis of aneurysms. This method can accurately evaluate the configuration of the aneurysm (e.g., any collateral supply) and the parent artery in real time, as well as analyze the expendability of the parent artery (i.e., any collaterals available to maintain the end-organ blood supply), which is necessary for procedural planning. Small aneurysms and other vascular abnormalities (e.g., arteriovenous fistula) that are not easy to identify on CT angiography may also be observed on DSA [4-6].

Various treatment options are available for hepatic artery aneurysms. Endovascular treatments are currently the most common, as these have higher success rates and more advantages in many circumstances [1].

The choice of endovascular treatment depends on multiple factors, including:

- Whether the lesion is a true aneurysm or pseudoaneurysm, as the latter should receive coil embolization with the sandwich technique in general [1].
- Whether the lesion is saccular or fusiform in shape, as endovascular treatment choices for fusiform aneurysms are limited relative to saccular lesions [1,5].
- Whether the parent arteries are expendable, that is, collaterals are available to maintain end-organ perfusion [3].

In consideration of these factors, multiple endovascular treatment modalities have been developed to accommodate various conditions. For instance, coils are frequently used. Sac packing is usually performed for aneurysms with narrow necks and saccular configurations, as shown in Case 5, which presented with a saccular-shaped lesion over the proximal right hepatic artery with a narrow neck. In other cases, the sandwich technique is adopted for lesions with potential collateral vessels, which involves embolizing both the afferent and efferent vessels to devascularize the entire lesion. This is shown in Case 1 (Fig. 1C), in which the lesion was located over a branch of the right hepatic artery and was likely to have multiple collaterals. Another method, namely stent-assisted coiling, can help preserve the patency of the parent artery [5]. This is performed by placing a stent across the aneurysm neck, which will act as the base during coil deployment into the pseudoaneurysm to prevent coil herniation into the artery lumen, ultimately leading to parent artery occlusion. This is particularly useful for lesions with wide necks, irregular shapes, or for those located in difficult regions, as illustrated in Case 4 (Fig. 4D, E).

Despite technical successes, aneurysm expansion or recurrence with or without rupture remains possible. As coiling requires thrombosis of the lesion or artery that is not immediate, regrowth with or without re-rupture is always possible before complete thrombosis. Direct coil embolization of the aneurysm sac may also cause expansion of the aneurysm sac with or without rupture owing to the coil volume. This was illustrated in Case 4, in which technical success of the pseudoaneurysm was achieved after initial stent-assisted coiling, but regrowth of the aneurysm with rupture occurred shortly thereafter. Despite another episode of successful embolization with obliteration of the left hepatic artery, recurrence still occurred along with involvement of the right hepatic artery. To date, there is still no convincing method that can prevent regrowth, and there is no well-recognized follow-up protocol for surveillance of recurrence.

Covered stents represent another endovascular treatment modality. These are often used when preservation of organ perfusion is not achievable with other endovascular options (e.g., for lesions over the hepatic artery proper) [1,5]. They were adopted in Cases 3 and 4 to preserve the flow of the common and right hepatic arteries respectively while achieving complete obliteration of the pseudoaneurysms.

Pipelines were deployed before insertion of the covered stents in these cases, which is not a routine practice. In typical cases, self-expanding covered stents are usually applied; however, self-expanding covered stents with the required calibers and lengths were not available due to logistic problems at the time. Therefore, balloon-mounted covered stents were used. To prevent rupture of vessels or the pseudoaneurysms caused by the large radial force generated during the expansion of the covered stents with a balloon, a pipeline flow diverter was deployed in advance, which acted as a scaffold for the procedure.

Despite their advantages, the use of covered stents is limited by the available delivery systems, vessel sizes (too small caliber may increase the risk of thrombosis), and stent rigidity (e.g., some may not be applicable for tortuous vessels) [1]. In addition, the need for antithrombotics after deployment of stents also limits their use, as many patients have relative or absolute contraindications (e.g., recent major surgeries). Currently, there remains an absence of an international consensus on the appropriate antithrombotic regimen for these patients; however, most interventional radiologists advocate that at least a single antiplatelet agent should be applied. Further research is therefore required to determine the appropriate regimen. At our center, an antithrombotic regimen was adopted from a regimen for elective endovascular neurointerventions, composed of Plavix 300 mg and aspirin 320 mg as loading doses and lifelong Plavix 75 mg and aspirin 80 mg daily as maintenance doses. However, the exact regimen should be individualized based on patients' risk of bleeding. In cases of recent major surgery (as in Cases 3 and 4), a single antiplatelet regimen

of aspirin with a loading dose of 320 mg and a maintenance dose of 80 mg daily lifelong was adopted instead of the usual dual antiplatelet regimen to reduce the risk of major postoperative bleeding.

Liquid embolic agents such as NBCA glue are available endovascular treatment modalities, and these are particularly effective for permanent occlusion of lesions from small or tortuous vascular branches, lesions with multiple collateral sources [6], or patients with an impaired clotting profile [5]. Despite the many advantages of liquid agents, it is not possible to embolize pseudoaneurysms originating from major arteries, which is necessary for the preservation of end-organ perfusion. NBCA glue was applied in Case 2, in which the pseudoaneurysm arose from hepatic segment six segmental artery, which has a small caliber and is not necessary for preserving hepatic perfusion.

Temporary embolization using gelfoam is also a possible endovascular treatment modality, as this method allows vascular injuries to heal during a short occlusion period [6].

Technical/angiographic success is usually defined as the confirmed absence of bleeding or complete obliteration of the pseudoaneurysm on post-treatment angiography [7]. Various endovascular treatment options have been proven to be successful angiographically in various studies and in our case series; however, as every option possesses unique advantages and disadvantages, no single option is particularly superior in handling various types of hepatic artery pseudoaneurysm at the time being.

Currently, our center is adopting the following workflow to choose the appropriate endovascular treatment options for confirmed cases of hepatic artery pseudoaneurysms:

- If the parent artery is not expendable, stent-assisted coiling or covered stents should be used. Stent-assisted coiling should be used if there is no good landing zone for the covered stent.
- If the parent artery is expendable, coil deployment or NBCA glue embolization should be considered. NBCA glue should be used if a patient has coagulopathy.

To the best of our knowledge, there are no well-recognized guidelines for the management of hepatic artery aneurysms. In our case series, various endovascular treatments were demonstrated and shown to be effective in treating lesions with varying causes and anatomies. Despite the small number of cases of hepatic artery aneurysms, further research on formulating treatment protocols for these lesions is necessary due to their high morbidity and mortality.

FUNDING

None.

CONFLICTS OF INTEREST

The authors have nothing to disclose.

ORCID

Pui Lam Cheung
https://orcid.org/0000-0002-7541-4588
Yat Sing Lee
https://orcid.org/0000-0002-3363-2640
Chong Boon Tan
https://orcid.org/0000-0002-1656-245X
Hin Yue Lau
https://orcid.org/0000-0002-1881-3750
Chi Wai Siu
https://orcid.org/0000-0001-9486-8377
Chik Xing Chan
https://orcid.org/0000-0003-2918-5080
Wai Tat Chan
https://orcid.org/0000-0001-6780-7202
Cheuk Him Ho
https://orcid.org/0000-0002-7115-7238

AUTHOR CONTRIBUTIONS

Concept and design: CPL, LYS, TCB. Analysis and interpretation: CPL, SCW. Data collection: all authors. Writing the article: CPL. Critical revision of the article: LYS, TCB, SCW. Final approval of the article: all authors. Overall responsibility: CPL.

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