Percutaneous direct puncture and embolization of vascularly inaccessible abdominal visceral pseudoaneurysms: A single-center experience and literature review

Yin-Chen Tsai[a,b], Hsiou-Shan Tseng[b,c], Edward W. Lee[d], Rheun-Chuan Lee[a,b], Nai-Chi Chiu[a,b], Hsuen-En Hwang[a,b], Chien-An Liu[a,b,e,*]

[a]Department of Radiology, Taipei Veterans General Hospital, Taipei, Taiwan, ROC; [b]School of Medicine, National Yang Ming Chiao Tung University, Taipei, Taiwan, ROC; [c]Department of Medical Imaging, Cheng Hsin General Hospital, Taipei, Taiwan, ROC; [d]Division of Interventional Radiology, Department of Radiology, UCLA Medical Center, Ronald Reagan Medical Center at UCLA, David Geffen School of Medicine at UCLA, Los Angeles, CA, USA; [e]Institute of Clinical Medicine, National Yang Ming Chiao Tung University, Taipei, Taiwan

Abstract

Background: To evaluate the techniques, efficacy, and safety for treating vascularly inaccessible abdominal visceral pseudoaneurysms by direct puncture and embolization.

Methods: A retrospective study of 5 consecutive patients who underwent percutaneous direct puncture embolization for intra-abdominal pseudoaneurysms in our institution between January 2009 and December 2016. Technical aspects, success, clinical outcome, and complications were discussed.

Results: Four patients (80%) were men, and the mean age of all five patients was 57.2 years (range, 47–72 years). The mean diameter of the pseudoaneurysms was 2.5 cm (range, 1.9–3.4 cm). All the pseudoaneurysms were punctured under the imaging guidance of fluoroscopy, ultrasound, or computed tomography. Coils and glue were used in four of the patients, the remaining one with coil only. The mean injected glue volume was 1.5 (range, 0.8–2) mL. The overall technical and clinical success rate was 100% without major complications or mortality.

Conclusion: Our single-center experience and the literature review demonstrate that percutaneous direct puncture embolization is feasible and effective to serve as an alternative for treating abdominal vascular pseudoaneurysms when the traditional endovascular embolization fails. In this approach, fluoroscopy is the most needed guidance technique.

Keywords: Aneurysm; Aneurysm, False; Fluoroscopy

1. INTRODUCTION

Rupture of an intra-abdominal visceral artery is typically life-threatening.[1] A high technical success rate and low periprocedural morbidity, transarterial embolization is the main treatment of choice for visceral artery aneurysms and pseudoaneurysms, especially in high-risk patients.[1,2] However, when endovascular-based treatment is not feasible, percutaneous direct puncture with embolization can be an alternative treatment. Several case reports and original articles had affirmed direct puncture and embolization of visceral pseudoaneurysms, including intrahepatic, superior mesenteric, and peripancreatic arterial pseudoaneurysms, were feasible.[3–7] Our patients were highly challenging, and we would like to document the approaches and preliminary outcomes of treating these vascularly inaccessible abdominal visceral pseudoaneurysms by direct puncture embolization under fluoroscopy.

2. METHODS

2.1. Patients

This study had received institutional review board approval, and informed consent had been waived. From January 2009 to December 2016, five patients had received percutaneous direct puncture with embolization of intra-abdominal visceral pseudoaneurysm after inaccessible endovascular approach.

2.2. Imaging guidance and percutaneous puncture

Imaging modalities including ultrasound, computed tomography (CT), and fluoroscopy were used to guide direct puncture of the pseudoaneurysms. Advantages of ultrasound guidance with color Doppler flow mapping are the real-time and without radiation exposure.

For an inconspicuous lesion, CT guidance either conventional CT or cone-beam CT to provide superior image resolution for

*Address correspondence. Dr. Chien-An Liu, Department of Radiology, Taipei Veterans General Hospital, 201, Section 2, Shi-Pai Road, Taipei 112, Taiwan, ROC. E-mail address: caliu@vghtpe.gov.tw (C.-A. Liu).

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visceral organs and a wider range of needle insertion angles during puncture. Reconstructed CT images are helpful for calculating the optimal gantry angle, and the aneurysmal sac can then be punctured parallel to the precalculated optimal angle under fluoroscopy.

Fluoroscopy is mandatory for the direct puncture. During fluoroscopic guidance for puncture, intermittent transcatheter contrast injection is used. The placement of the endovascular catheter and wire helped to localize the aneurysms. Existing radiopaque materials such as a surgical clip, drainage tube, or vascular calcification can be used as landmarks. When the site of aneurysm is confirmed and punctured, the inner stylet of the puncture needle should be withdrawn to observe for brisk or pulsating blood return, which suggests the optimal intra-aneurysmal position of the needle tip. Subsequently, a low volume of diluted contrast should be gently injected into the sac to confirm the needle tip location and sac flow.

2.3. Embolization and follow-up

Pushable coils (Tornado or Nester; Cook) and n-butyl cyanoacrylate (NBCA; Histoacryl; Braun, Sempach, Switzerland) mixed with ethiodized oil (Lipiodol; Andre Guerbet, Aulnay-Sous-Bois, France) were the most frequently used embolic agents. When the size of the aneurysm sac was large or marked turbulent flow was observed within the sac, coil embolization was performed first to reduce the flow and minimize the risk of nontarget glue embolization. Then NBCA mixture was injected carefully at a continuous rate until sufficient opacification filled into the sac. To achieve complete embolization, needle tip adjustment or repeated sac puncture might be needed.

2.4. Technical and clinical end point

Angiography was performed after embolization, and technical success was defined as no contrast enhancement found in the aneurysmal sac. To monitor the treatment outcomes, imaging follow-up with triple-phase contrast-enhanced CT or magnetic resonance imaging was scheduled 1 to 2 months afterward. Clinical success was defined as cessation of bleeding and without rebleeding within 30 days.

3. RESULTS

3.1. Characteristics of patients and imaging guidance of direct puncture

The baseline characteristics and embolization details of patients are summarized in Table 1. Four patients (80%) were male and one was female with a mean age of 57.2 years (range, 47–72 years). The mean diameter of the pseudoaneurysms was 2.5 cm (range, 1.9–3.4 cm). Patient #1 had a hepatic artery pseudoaneurysm following cholecystectomy. Iatrogenic dissection occurred during endovascular treatment, rendering the feeding artery inaccessible. Purely fluoroscopic guidance puncture was performed by using the surgical clip as a reference. Patient #2 had a peripancreatic pseudoaneurysm caused by chronic pancreatitis. The feeding artery arised from the splenic artery was inaccessible. Intermittent transcatheter contrast injection to opacify the pseudoaneurysm followed by fluoroscopically guided puncture was performed. Patient #3 (Fig. 1) had a ruptured hepatic artery near the anastomosis following liver transplantation, and the bleeding site could not be selected because the feeding artery had a sharp angle. He underwent ultrasound-guided puncture with color Doppler flow mapping (Fig. 1A) followed by fluoroscopic guidance. The placement of the endovascular catheter and wire (Fig. 1C) also facilitated the localization and puncture of the aneurysm. Patient #4 (Fig. 3) experienced a type I endoleak with rebleeding after stent graft placement for postpancreatectomy

Table 1

Characteristics and procedural details of patients

Patient number	Gender and age, y	Pseudoaneurysm parent artery	Pseudoaneurysm size, cm	Etiology	Imaging guidance modalities	Puncture needle	Embolic agents	Technical success	Parent arterial patency	Minor or major complication	Imaging follow-up
1	Female, 59	Dissected replaced common hepatic artery	2.4 × 1.8	Laparoscopic cholecystectomy	Fluoroscopic guidance	18G Chiba + microcatheter	0.018" microcoils, 1:4 NBCA, 1.5 mL	Yes, complete embolization	Occluded, hepatic artery	Transient elevated liver enzymes	One-month CT, no recanalization
2	Male, 55	Splenic artery	2.7 × 2.4	Chronic pancreatitis	Fluoroscopic guidance	21G Chiba	0.018" microcoils, 1:2 NBCA, 1.6 mL	Yes, complete embolization	Patent	No	Two-month CT, no recanalization
3	Male, 47	Common hepatic artery	2.1 × 1.5	Ruptured hepatic artery/LDLT	Ultrasound guidance, followed by fluoroscopy	21G Chiba	0.018" microcoils	Yes, complete embolization	Patent	No	Six-month CT, no recanalization
4	Male, 72	Junction of GDA stump and LHA	3.4 × 2.2	Type I endoleak/post-PPPD hemorrhage	Reconstructed dynamic CT images as reference and fluoroscopic guidance	21G Chiba	0.018" microcoils, 1:3 NBCA, 2 mL	Yes, complete embolization	Occluded, dissected hepatic artery	Minimal glue spillage, transient elevated liver enzymes	One-month CT, no recanalization
5	Male, 53	Branch of pancreatic magna artery	1.9 × 1.2	Necrotizing pancreatitis	CT guidance, followed by fluoroscopy	18G Chiba	Coils 0.035, 1:3 NBCA, 0.8 mL	Yes, complete embolization	Patent	No	One-month MRI, no recanalization

CT = computed tomography; GDA = gastroduodenal artery; LDLT = living donor liver transplant; LHA = left hepatic artery; MRI = magnetic resonance imaging; NA = not available; NBCA = N-butyl cyanoacrylate; PPPD = pylorus-preserving pancreatoduodectomy.

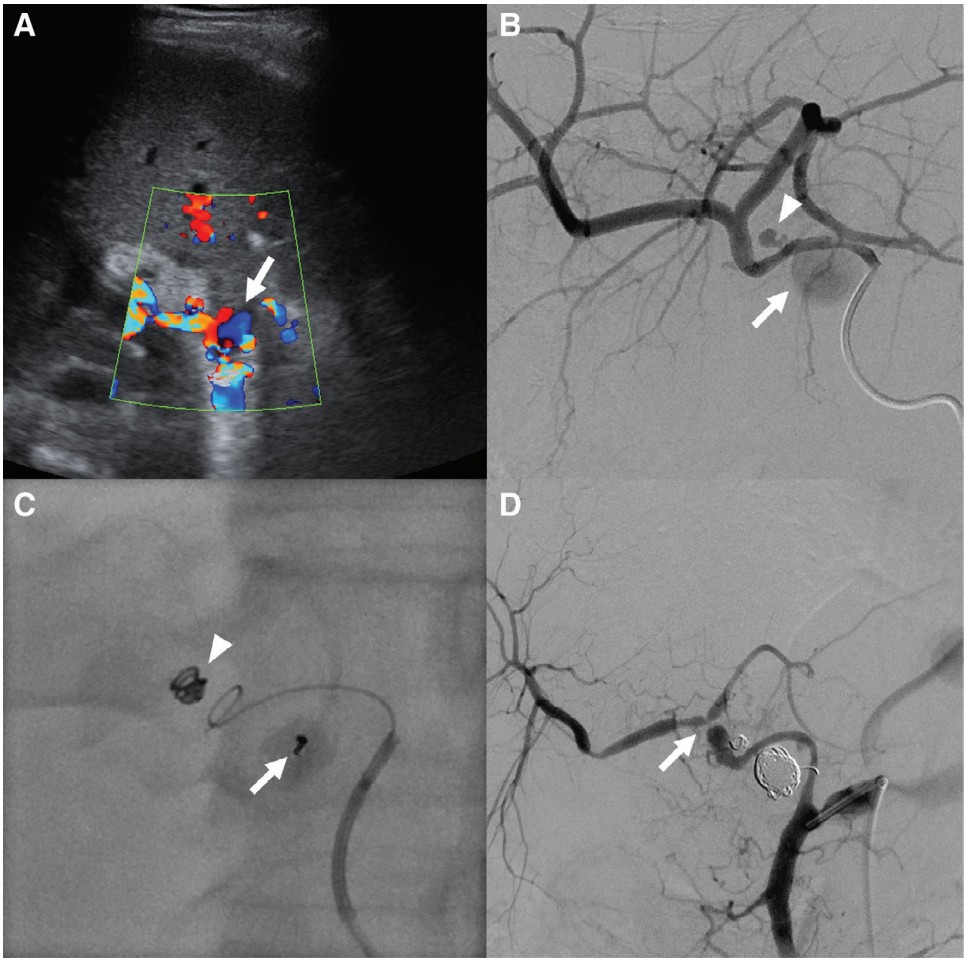

Fig. 1 A 47-y-old man underwent orthotopic liver transplantation to treat hepatocellular carcinoma. **A,** Follow-up ultrasound study one month after surgery revealed a 2.1-cm aneurysm near the hepatic hilum (arrow). **B,** Hepatic arteriography revealed two outpouching pseudoaneurysms (arrow and arrowhead) near the hepatic artery anastomosis. **C,** Endovascular coil embolization was performed for the small pseudoaneurysm (arrowhead) but failed on the large one. The large pseudoaneurysm was then punctured percutaneously using a 21-gauge Chiba needle (arrow) under fluoroscopic and ultrasound guidance, and coil embolization was performed successfully. **D,** Follow-up angiogram one month after the procedure showed total obliteration of both pseudoaneurysms. The proper hepatic artery was patent; however, a newly formed stenosis (arrow) was noted at the junction of the right and left hepatic arteries.

gastroduodenal stump bleeding. Direct puncture with fluoroscopic guidance was performed with reference to reconstructed CT images (Fig. 3B) and taken advantage of preexisting radiopaque landmarks (metallic stent and drainage tube; Fig. 3C, D). Patient #5 (Fig. 2) had peripancreatic pseudoaneurysms that had evolved from necrotizing pancreatitis, and the feeding arteries were tortuous branches of the pancreatic magna artery, which was inaccessible from the splenic artery. CT-guided puncture (Fig. 2A) followed by fluoroscopic guidance was done.

For each patient, once a successful aneurysm puncture was confirmed, subsequently, a small volume of diluted contrast should be gently injected into the sac to confirm the needle tip location and sac flow (Fig. 1C, 3C, D) under fluoroscopy.

3.2. Embolization techniques

Pushable coils and NBCA mixed with ethiodized oil, which were used separately (#3, Fig. 1D; #5, Fig. 2B, D) or sequentially (#4, Fig. 3E) through the puncture needle or catheter, were the two mainly used embolic agents among the five patients (Table 1). In three cases, marked turbulent flow was observed within the sac (#1, #2, and #4), and coil embolization was performed first to reduce the flow and minimize the risk of nontarget embolization. The ratio of the injected NBCA mixture was 1:2 to 1:4 and the volume ranged from 0.8 to 2.0 (mean, 1.5) mL.

3.3. Outcome of direct puncture and embolization

Immediate follow-up angiography confirmed the obliteration of the aneurysm sac in four patients. Residual aneurysm sac was observed in one patient, and we adjusted the needle tip position and repeated sac puncturing to achieve complete embolization (#5, Fig. 2C). Technical and clinical success was achieved in all patients without rebleeding. Procedure-related minor complication with postprocedural transient elevation of liver enzymes after occlusion of hepatic artery due to nontarget embolization were noted in two patients (#1 and #4). There was no major complication encountered.

4. DISCUSSION

The fluoroscopic guidance was essential for the lesion targeting, the needle tip confirmation, and the embolization process. Ultrasound-guided puncture under color Doppler flow mapping with coils and NBCA glue embolization has been utilized when treating the hepatic artery and peripancreatic pseudoaneurysms.[3,8] However, when intra-abdominal visceral aneurysms are not well visualized by ultrasound because of the hyper echogenicity of gas in hollow organs, visceral organs, or hematomas, other imaging modalities such as CT can be used.

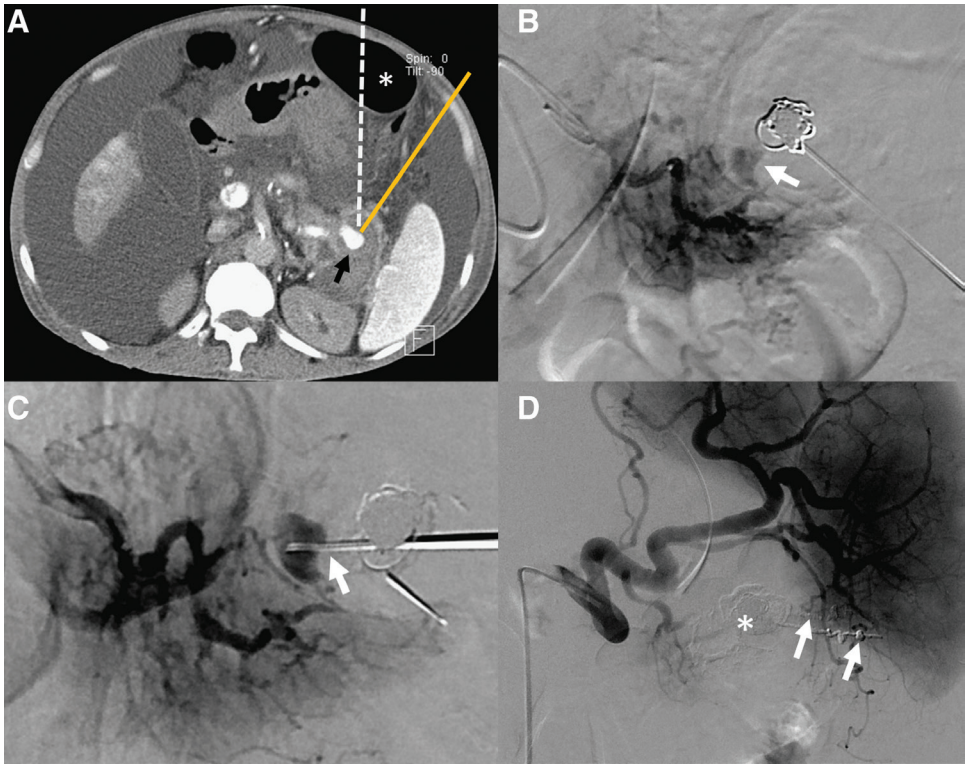

Fig. 2 A 53-y-old man had necrotizing pancreatitis. **A,** Contrast-enhanced computed tomography (CT) at arterial phase revealed a 1.9-cm pseudoaneurysm in the necrotic tissue of the pancreas tail (arrow). Fluoroscopy-guided direct puncture embolization was selected for treatment after endovascular embolization had failed. The optimal gantry and puncture angles (solid line) were calculated relative to the anterior-posterior angle (dashed line) on the axial CT slice to avoid injury to the colon (asterisk). **B,** Follow-up angiography revealed residual vascular stain (arrow) after coil embolization through an 18-gauge Chiba needle. **C,** Under fluoroscopic guidance, the needle was adjusted and advanced to the residual sac (arrow). **D,** Follow-up splenic arteriography showed total obliteration of the pseudoaneurysm (asterisk); tract embolization with n-butyl cyanoacrylate glue was subsequently performed (arrows).

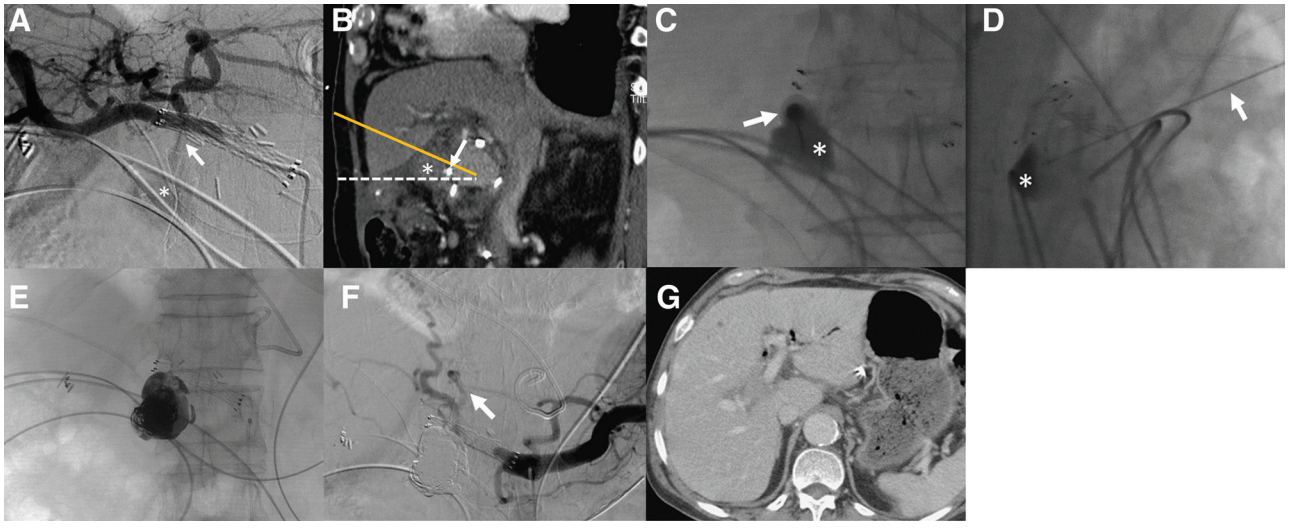

Fig. 3 A 72-y-old man with adenocarcinoma of the pancreatic head underwent pancreaticoduodenectomy. Gastroduodenal artery stump bleeding occurred 25 d after surgery. Covered stent placement was initially performed, and a follow-up diagnostic angiography was done. **A,** Rebleeding with pseudoaneurysm (asterisk) due to type I endoleak from the distal left hepatic artery (arrow) was noted on the follow-up angiography. To seal the stent with balloon was tried; however, postdilatation arterial dissection was noted during the procedure. To avoid additional complications, direct puncture was performed instead of transcatheter therapy. **B,** The optimal gantry and puncture angle (solid line) were calculated relative to the anterior-posterior angle (dashed line) on a sagittal computed tomography (CT) slice to prevent injury to the jejunum (asterisk). One of the drainage tubes (arrow) was used as a landmark for direct puncture. **C and D,** Frontal and lateral biplane observation with contrast injection confirmed the location of the needle tip (arrow) in the aneurysmal sac (asterisk). **E,** After coil and n-butyl cyanoacrylate glue embolization, a follow-up celiac angiography revealed occlusion of the hepatic artery. **F,** Delayed opacification of the left hepatic artery from collaterals of the proximal left hepatic artery was observed (arrow). **G,** Follow-up dynamic CT one month after embolization revealed no ischemic change in the liver parenchyma.

We performed literature review and summarized in Table 2. They confirmed fluoroscopy was the most needed guidance to approach the abdominal visceral pseudoaneurysms for direct puncture. The ultrasound, 3D rotational digital subtraction angiography (DSA), and CT are complementary image modalities to enhance safety and accuracy. Although increased usage of the 3D rotational DSA and CT was noted over the last decade as technology advances, ultrasound is still more commonly used than other devices because of its high accessibility. As the auxiliary equipment of splanchnic puncture, the real-time needle track visualization to avoid vulnerable anatomy is indispensable.[18] Previous case reports had described direct puncture of pseudoaneurysms with needle sizes ranging from 23 to 18 gauge.[5,7] Though a 22- or 23-gauge needle is relatively safe, however, the shaft of a long thin needle is not rigid enough to support an accurate puncture through the solid visceral organs and reach the aneurysm. We prefer to use a 21-gauge or larger needle for its sufficient rigidity and better controllability. But a 21-gauge needle is not large enough to allow a currently available microcatheter to pass through. By using an 18-gauge or a larger bore needle, a microcatheter such as the 2.5F Renegade Hi-Flo microcatheter (Boston Scientific, Natick, MA, USA) can be advanced directly through the needle for selective angiography and subsequent embolization (#1 and #5). Rupture of an aneurysm or pseudoaneurysm during direct puncture embolization is a concern, but no such ruptures had been reported in the literature.[3–5,7,9,10] Slow blood aspiration through the puncture needle and gradual coil packing during embolization are likely to lower the risk of rupture because of a decrease in intra-aneurysmal pressure. In each of our five patients, we used a 21- or 18-gauge puncture needle and no aneurysmal rupture during the procedures.

For pseudoaneurysms in extremities, ultrasound-guided thrombin injection can achieve an initial clinical success rate of 97%–100%.[18] In our patients, we used coils and NBCA glue rather than thrombin because thrombin cannot be monitored in real time under fluoroscopy and poses a high risk of nontarget embolization or thrombosis. Some other embolic agents such as ethanol[14] or thrombin[6,12,13,15–18,24] can be used as well, depending on the operator's familiarity with and preference for the supplies.

In our study, we used pushable coils alone or a combination of coils and NBCA glue as embolic materials. According to the flow dynamics inside an aneurysm and the risk of nontarget embolization, the ratio of NBCA to lipiodol is typically 1:1 to 1:3.[6,9–11,13,19,22] As this ratio increases, the polymerization time is prolonged, possibly increasing the risk of nontarget embolization. To prevent glue spillage and to protect other vessels from nontarget embolization, an intravascular balloon can be inflated during the procedure.[19] Unintended embolization and subsequent thrombosis of a nontarget vessel is one of the most serious complications that can occur. However, organs with abundant collateral circulation are believed to be more tolerant of nontarget embolization than are other organs.[6] In this study, unintended occlusion of the dissected hepatic artery during an attempt to obliterate the pseudoaneurysm in two patients who exhibited postprocedural transient elevation of liver enzymes without hepatic ischemia or infarction in follow-up images (#4, Fig. 3G and #1).

In conclusion, our single-center experience emphasizes that fluoroscopy is the most needed guidance to approach the abdominal visceral pseudoaneurysms by percutaneous direct puncture and additionally proves this technique is a feasible and effective treatment for patients with endovascular inaccessible abdominal vascular pseudoaneurysms.

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Table 2

Literature summary on pseudoaneurysm percutaneous embolization

	Case number	Pseudoaneurysm size, mm	Imaging guidance modalities	Embolic agents	Technical success	Minor or major complication
Gorsi et al[9]	21	Not mentioned	CT (4), ultrasound + fluoroscopy (17)	NBCA	21 (100%)	Minimal pneumothorax (2), reflux into intercostal artery (1)
Kumar et al[10]	26	10–30	Ultrasound + fluoroscopy (26)	NBCA (23), coil (1), NBCA + coil (2)	26 (100%)	Self-limiting abdominal pain (25), splenic infarct (6), liver abscess (1)
Yadav et al[11]	4	11–28	Ultrasound + fluoroscopy (4)	NBCA (4)	4 (100%)	NA
Barbiero et al[12]	1	20	Ultrasound (1)	Thrombin	1 (100%)	NA
Dik et al[6]	10	7–30	Ultrasound, fluoroscopy, and cone-beam CT (10)	NBCA (6), coil (3), thrombin (1)	10 (100%)	NBCA spilling into feeding artery without symptoms (5)
Vyas et al[13]	5	6–42	Ultrasound + fluoroscopy (5)	NBCA (3), thrombin (2)	4 (80%), reintervention (1)	NA
Yagi Yoshida et al[7]	1	9	CT + fluoroscopy + 3D rotational DSA (1)	NBCA (1)	1 (100%)	NA
Vyas et al[14]	1	16	Ultrasound (1)	NBCA (1)	1 (100%)	NA
Fankhauser et al[15]	5	Not mentioned	Ultrasound (5)	Coil (2), thrombin (3)	4 (80%), reintervention (1)	NA
Santiagu et al[16]	1	Not mentioned	Ultrasound + fluoroscopy (1)	Thrombin	1 (100%)	NA
Ward et al[17]	1	30	CT (1)	Thrombin	1 (100%)	NA
Ghassemi et al[18]	1	51	CT (1)	Thrombin	1 (100%)	NA
Gulati et al[19]	1	35	Ultrasound + fluoroscopy (1)	NBCA (1)	1 (100%)	Jejunal stricture
Laganà et al[8]	2	45–50	Ultrasound (2)	Thrombin (2)	Reintervention (2)	NA
Nicholson et al[20]	4	Not mentioned	CT (4)	Thrombin (4)	Reintervention (4)	NA
Puri et al[21]	1	50	CT (1)	Thrombin (1)	Reintervention (1)	NA
Araoz et al[5]	3	12–20	Fluoroscopy (3)	Coil (3)	2 (66.7%), reintervention (1)	Biliary obstruction (1)
Kuno et al[22]	1	Not mentioned	Fluoroscopy (1)	Coil (1)	1 (100%)	NA
Capek et al[23]	1	40	Ultrasound (1)	Coil (1)	1 (100%)	NA
Lukancic et al[4]	1	Not mentioned	Fluoroscopy (1)	Coil (1)	1 (100%)	NA

The numbers in parentheses indicate the case number and percentage.

3D = three dimensional; CT = computed tomography; DSA = digital subtraction angiography; NA = not available; NBCA = n-butyl cyanoacrylate.

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