Original Article

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Percutaneous Imaging Guided Puncture and Embolization of Visceral Pseudoaneurysms

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Background: Visceral pseudoaneurysms (PSAs) are usually treated endovascularly. No official guidelines exist regarding the correct management when this management option fails. The aim of this study is to assess the efficacy and safety of percutaneous imaging guided puncture of visceral PSAs in patients where intra-arterial embolization was unsuccessful or unfeasible.

Methods: Five patients with visceral artery pseudoaneurysms (VAPAs) were enrolled in the study. The diagnosis was made using a 64-slice multi-detector computed tomography (MDCT) scanner and all patients were previously considered unsuitable for the procedure or underwent the procedure unsuccessfully; all patients had anemia with hemoglobin loss greater than 2 g/dL in the last 24 hours. A 22-gauge Chiba needle was used to get percutaneous access to the lesion, where N-butyl cyanoacrylate (NBCA) and lipiodol or coils and onyx were subsequently injected.

Results: Four patients received a mixture of NBCA and lipiodol in a 1:2 ratio (80%, $n = 4$), and only one participant received coils and onyx. Primary clinical success was 100% and embolization was not repeated in any cases. No life-threatening secondary conditions or major complications were observed throughout the follow-up period; in one patient an asymptomatic embolic agent migration was reported. Secondary clinical success was also obtained in the current study. None of the remaining four participants experienced re-bleeding episodes or any procedure-related problems.

Conclusions: Percutaneous embolization of visceral PSAs is a safe and effective treatment alternative that should be considered when the trans-arterial method cannot be used.

Keywords: *Visceral; Pseudoaneurysm; Percutaneous; Trans-arterial; Embolization*

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INTRODUCTION

Pseudoaneurysms (PSAs) are vascular conditions characterized by a severe disruption in the continuity of the arterial walls. The debilitating damage to the arterial lining results in the formation of an adventitia-lined sac [1]. According to the literature, the debilitating nature of this abnormality is evidenced by literature findings that show that the secondary conditions that developed due to PSAs are related to both high mortality and morbidity rates [2]. Patients diagnosed with PSAs might experience deteriorating health linked to the development of a wide spectrum of chronic conditions that can result from the compression of neurovascular structures, infections, or deep vein thrombosis [1]. Ultimately, the efficacy of the medical treatments used to manage PSAs are primarily based on the early diagnosis of the condition before it progresses into debilitating stages.

The leading causes of the formation of PSAs are events that cause disruption in the continuity of the arterial wall, such as trauma, anastomotic disruptions, accidental intra-arterial delivery of controlled substances, localized inflammatory reactions, and invasive procedures [1]. Around 75% of all accidental intra-arterial drug injections occur at the lower limb; the latter has been found to be the most frequent site of PSA formation [3].

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Imaging can clarify the condition's progression by displaying the blood's speed and movement pattern inside the artery, measuring the PSA diameters and showing the sac's communication with the artery, and the presence of contrast. The detectable symptoms considered in diagnosing PSAs are caused directly by the presence of the PSA itself, its rupture, or the secondary effects of the mass on adjacent neuro-vascular structures.

The main diagnostic tool used in emergency settings is contrast-enhanced computed tomography (CE-CT) [4].

Although surgery has been the first line of treatment in PSA management for years, interventional radiology procedures have proven to be a safe and effective alternative. One primary interventional treatment approach is the endovascular exclusion of the PSA, achieved through different tools such as stents, coils, and injectable liquids, each one with their use case depending on the nature, size, and location of the PSA, but also on the team's experience and preference. Radiological methods possess some clear advantages over traditional open surgery, with lower invasiveness and less post-procedural complications as the main ones, avoiding some of the risks associated with open surgery and allowing patients unfit for such procedures to be treated. One of the most widely adopted radiological treatments is trans-arterial embolization [5].

This study's aim is to report the outcome of percutaneous PSA embolization in patients for whom a trans-arterial approach was attempted but was unsuccessful. The study also attempts to propose another option in treating visceral arterial pseudoaneurysms (VAPAs).

MATERIALS AND METHODS

Patients

The patient group analyzed in this study consisted of patients for whom the trans-arterial embolization approach was unsuccessful. All of the diagnoses were made using multidetector CT employing a 64-slice CT scanner. Trans-arterial embolization was attempted in all cases but was deemed ineffective due to the impossibility to catheterize the feeding PSA artery, inadequate catheterization of the feeding artery and/or an inability to catheterize the "exit" artery beyond the PSA.

The sample consisted of five patients, of whom three were males and two were females. Patient selection was based on the need to have a representative population so that the results of the current research could be extrapolated and generalized.

Inclusion and Exclusion Criteria

The subjects included in the trial had severe anemia, characterized by a hemoglobin level loss greater than 2 g/dL within 24 hours that could be attributed to recent bleeding. All of the patients included were hemodynamically stable or achieved stability through resuscitation techniques.

Outcomes

Technical success: Total embolization of the PSA at the end of the procedure.

Primary Clinical success: Stabilization of the patient's vitals and hemoglobin level recovery within 5 to 6 days after the procedure.

Secondary Clinical success: Absence of bleeding recurrence over the 12-month follow-up period, demonstrated at CE-CT follow-up performed before discharge, at 6 months and at 12 months after the procedure.

Safety: Major and minor complications were classified and recorded in accordance with the standard operating procedure stipulated by the Cardiovascular and Interventional Radiology Society of Europe [6].

The Intervention and its Follow-Up

The intervention deployed in the current study was the percutaneous procedure. Three interventional radiologists with more than 15 years of experience in endovascular and percutaneous techniques were tasked to perform the procedures on an angiographic table. Arterial access via the femoral artery was obtained using a 5 Fr vascular access sheath in all of the patients. Cobra C1 or Simons 1 catheters were used to catheterize the celiac trunk or, in some patients, the mesenteric arteries. The operators then used an angiogram and an improved cone-beam CT (CB-CT) scan to identify the PSAs and the affected artery location. To superselectively access the target arteries, a 2.7 Fr Progreat microcatheter was used. Notably, trans-arterial catheterization could not be achieved in any of the participants in our series due to the aforementioned anatomical characteristics.

The PSA diagnosis was performed through imaging processes such as ultrasound (US) and fluoroscopy, and defined as a pooling of contrast agent in the lumen of the affected arteries. The operator used a 22-gauge Chiba needle to get percutaneous access to the lesion. Subsequently, a sacculography was performed before every injection to ensure that the needle location was accurate, using US and fluoroscopic supervision and sometimes performing numerous angiography examinations in different projections to improve needle progression. The embolic agents of choice were either a mixture of N-butyl cyanoacrylate (NBCA) and lipiodol or coils and polymer. NBCA and lipiodol were used at a 1:2 ratio respectively, and a total 0.2–0.6 mL of the resulting liquid mixture was injected once or twice if deemed necessary by the researchers. The Chiba needle was

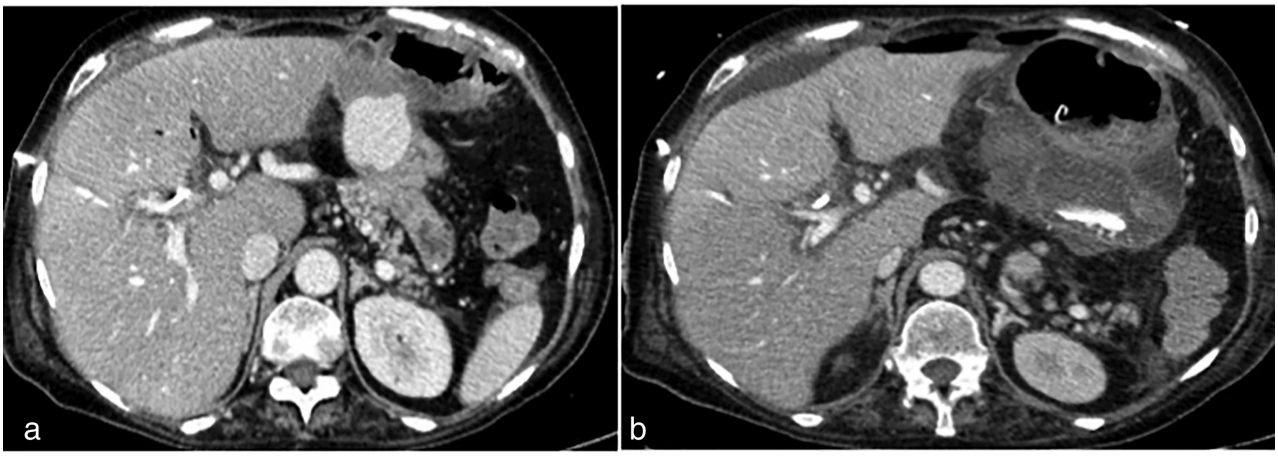

Figure 1 PSA acute bleeding. **(a)** a 40 mm PSA of the pancreatico-dorsal artery in a patient who underwent duodenocefalopancreasectomy with consequent anastomotic dehiscence. **(b)** Active contrast agent extravasation demonstrates acute bleeding from the PSA.

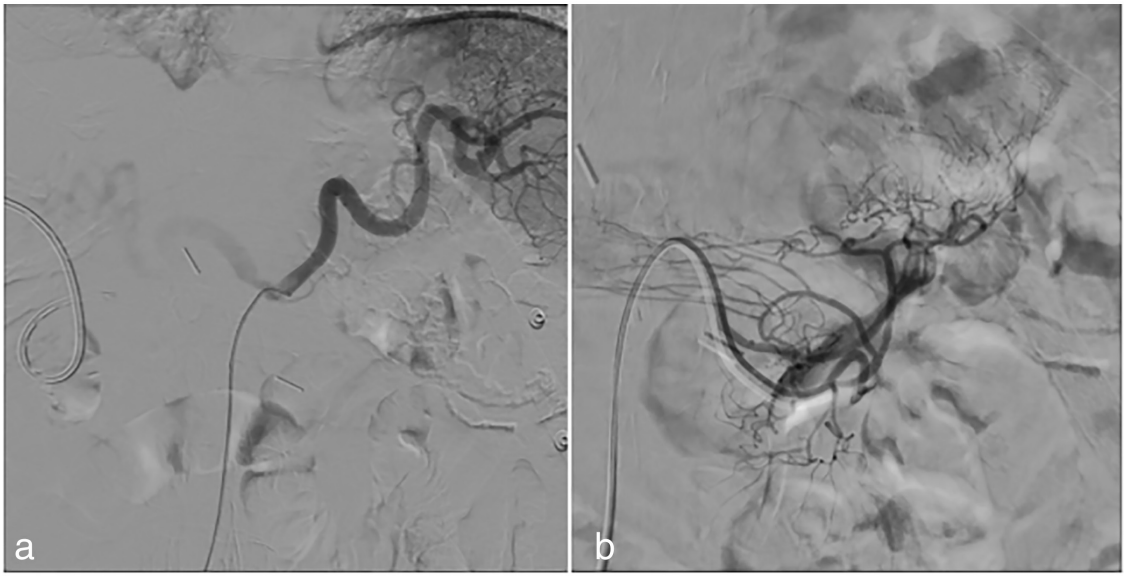

Figure 2 Angiogram. **(a)**, **(b)** Selective angiogram did not show a PSA.

periodically cleaned with a 5% dextrose solution prior to the administration of the NBCA glue; the administration of the glue was guided through fluoroscopy and only stopped when the PSA was filled or when slight extravasation of glue was noticed. Regardless of the embolic agent utilized, the Chiba needle was removed after embolization was complete, performing a final assessment through US or angiography to ensure the correct exclusion of the PSA from circulation and therefore confirming technical success.

In a single case, coils and polymer were used to fill a PSA characterized by the exceptionally large diameter of 40 mm (Figure 1*a,b*); arteriograms did not reveal the PSA (Figure 2*a,b*); in this case, a sheath, a diagnostic catheter and a microcatheter (Progreat 2.7 Terumo) were used. Polymer (Onyx 18, Medtronic) and coils were used to completely fill the PSA (Figure 3*a–d* and Figure 4).

Experiment Findings

The total embolization of the PSAs was observed at the end of the percutaneous procedures in all of the patients, proving a technical success of 100% in our sample. Primary and secondary clinical successes were obtained in all of the patients as well.

The maximum monitoring period was 72 months and, throughout that period, major and minor complications were recorded; the incidence of bleeding recurrence and embolic material migration were monitored.

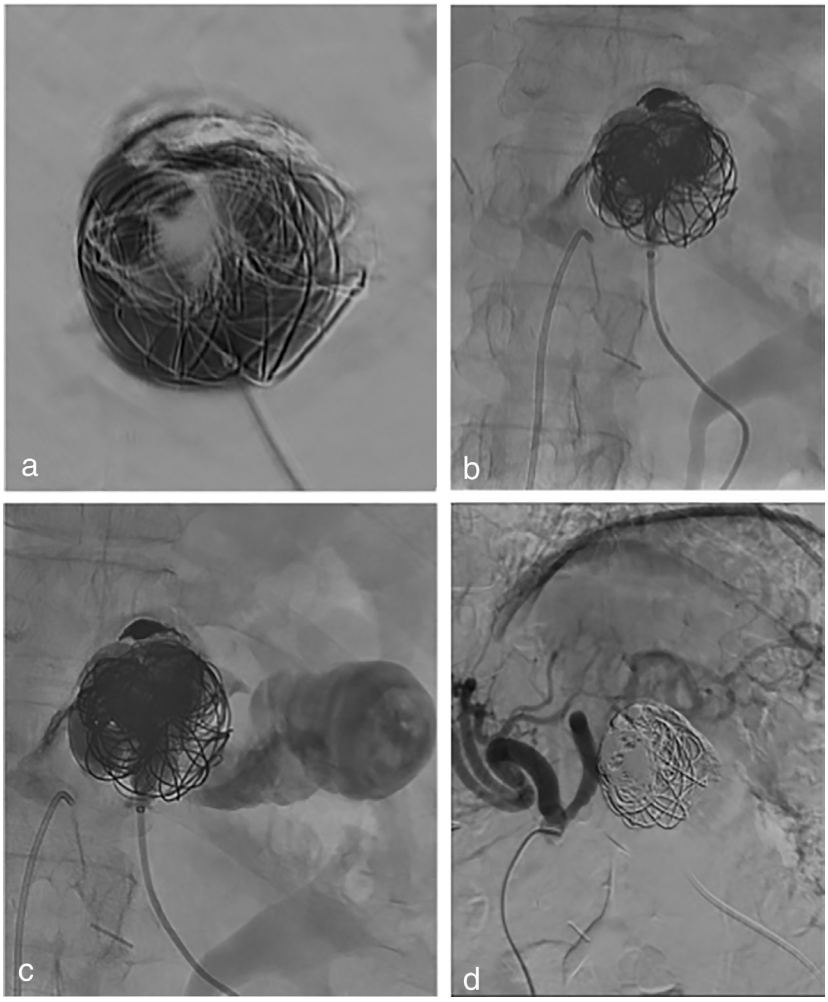

Figure 3 Percutaneous PSA embolization. **(a)**, **(b)**, **(c)**, **(d)** Percutaneous puncture of the PSA and embolization with coils and non-adhesive fluid (Onyx).

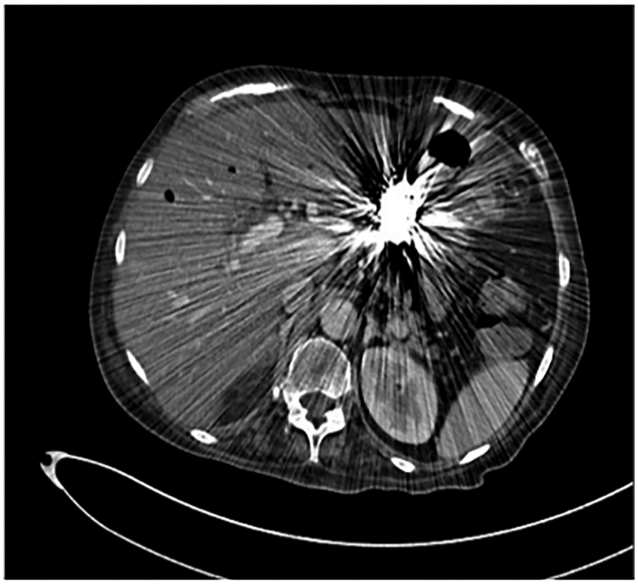

Figure 4 Control CT scan. The CT scan showed no signs of vascularization within the treated PSA and absence of active bleeding.

Ethical Approval and Informed Consent

The study was conducted in compliance with the Declaration of Helsinki, a set of ethical principles regarding human experimentation and data collection. Prior to the beginning of the study, informed consent forms were obtained from patients or relatives if patients were deemed incapable of rational decision-making.

RESULTS

The five participants in this study had a median age of 52 years, and the mean PSA size was 27.2 mm. The etiology related to the development of PSAs among the patient population was heterogeneous and included biliary procedures, surgery, trauma, and pancreatitis.

Using CE-CT imaging, the location of each of the PSAs was determined: the vessels involved were the right hepatic artery, the left gastric artery, the digiunal artery, the first jejunal artery, and the pancreatic artery, as shown in Table 1.

Table 1 Patient characteristics and embolization information.

Patient ID	*Gender*	*Age*	*Cause*	*PSA-Affected Area*	*PSA Diameter (mm)*	*Embolic Agent*	*Developed Complication*
1001	M	38	Biliary operation	Right hepatic	22 mm	22G, glue	No
1002	F	51	Pancreatitis	Left gastric	30 mm	22G, glue	No
1003	F	56	Surgical procedure	Digiunal	24 mm	22G, glue	No
1004	M	60	Trauma	First jejunal	20 mm	22G, glue	Asymptomatic embolic material migration
1005	M	55	Surgical procedure	Pancreatic artery	40 mm	Microcath coils + onyx	No

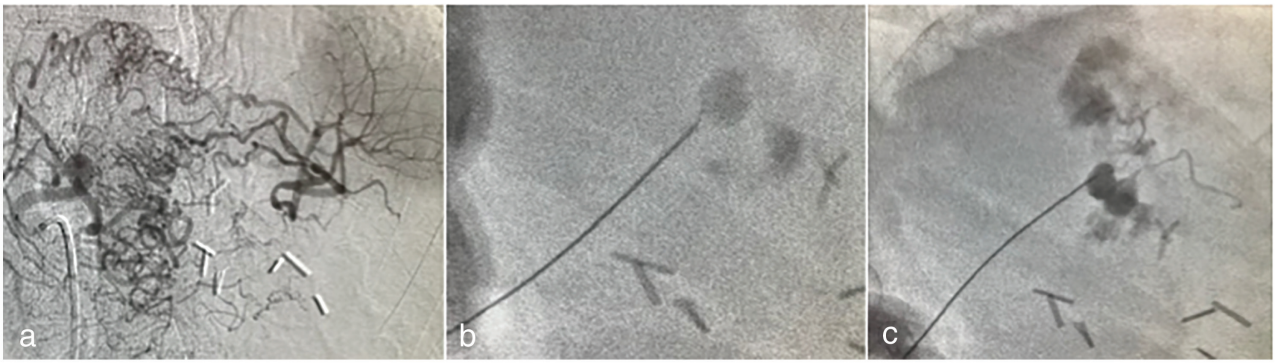

Figure 5 Left gastric PSA percutaneous embolization. **(a)** Left gastric PSA unreachable via transarterial. **(b)** Percutaneous fluoroscopic guidance puncture with 22G needle. **(c)** Embolization with glue.

The analysis revealed that the maximum and minimum PSA diameters were 40 mm and 20 mm, respectively. In the study, four patients received a mixture of NBCA and lipiodol in a 1:2 ratio (80%, n = 4) (Figure 5*a–c*), and only one participant received the coils + polymer combination. Primary clinical success was 100%, as normal hemoglobin levels were reported in all patients after the embolization. As a result, embolization was not repeated in any cases, and no more blood transfusion was required during their hospital stay. Notably, no life-threatening secondary conditions were observed during the treatment; no major complications were observed throughout the follow-up period; in one patient an asymptomatic embolic agent migration was reported.

Secondary clinical success was also obtained in the current study, as evidenced by both the absence of re-bleeding over the 72-month outpatient monitoring period and the complete pseudoaneurysm embolization. One patient died during the follow-up period, but the death was caused by cancer-related complications, unrelated with the subject of this study. None of the remaining four participants experienced re-bleeding episodes or any procedure-related problems, proving the procedures' potential in excluding PSAs from the circulation in subjects where trans-arterial approaches cannot be deployed or have already been tried unsuccessfully. Ultimately, those results show that the procedure is feasible, safe, and useful as a treatment option in this subcategory of patients.

DISCUSSION

Pseudoaneurysms are caused by a disruption in the continuity of the arterial walls, resulting in the formation of a sac that communicates with arterial lumen [1]. Causes of PSAs include invasive surgery, intravenous drugs delivery, perivascular inflammation, and trauma to the artery wall [7].

In the past, PSAs were almost exclusively treated through invasive surgical procedures. However, literature linked such interventions with higher morbidity and mortality rates, highlighting the need to explore efficient but less invasive procedures [8].

This resulted in the discovery and widespread adoption of a broad array of endovascular approaches that have seen a constant growth in the variety of treatment options, their efficacy, and their safety [1].

Less invasive procedures are popular because they can be deployed to eliminate PSAs that could be surgically difficult to correct and to treat patients that have been deemed unfit for open surgery.

The endovascular approach, despite having a high success rate, can be unfeasible in treating PSAs in some patients. Notably, percutaneous embolization requires the adoption of imaging modalities as guidance during percutaneous therapy (including US, CT, and fluoroscopy). All of these imaging methods can be used on their own or they can be combined in various ways to make the approach both easier and more accurate [9]. Contextually, the current study examined the effectiveness of percutaneous imaging guided puncture in cases where trans-arterial approaches were not feasible in the treatment of PSAs, such as, for instance, when the artery affected by the PSA is inaccessible.

Our study's clinical and technical success rates were 100%, with no cases of recanalization, re-bleeding, or the development of debilitating secondary conditions.

In our small series, the rate of minor complications was so low that it can be considered almost negligible. However, caution must be adopted when performing percutaneous puncture. As mentioned above, our study's limitations include its small sample size and the heterogeneity of etiology behind the PSAs of patients in the sample.

CONCLUSION

Our study demonstrates that percutaneous embolization of visceral PSAs is a safe and effective treatment alternative that should be considered when the trans-arterial method is not feasible. Nonetheless, the procedure should be performed by experienced operators and in selected cases, as more extensive studies in terms of population size are still lacking.

Ethics Statement

(1) All the authors mentioned in the manuscript have agreed to authorship, read and approved the manuscript, and given consent for submission and subsequent publication of the manuscript.
(2) The authors declare that they have read and abided by the JEVTM statement of ethical standards including rules of informed consent and ethical committee approval as stated in the article.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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Author Contributions

All the authors substantially contributed to the study and manuscript writing.

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