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Case Report

Sequential Aspiration and injection of a Mixture of gelatin-based hemostatic agent and autologous blood clot followed by suture coiling for Effective Embolization of splenic artery pseudoaneurysm by interventional Radiologist (SAMEER): Description of a novel technique ☆

Sameer Peer[a,*], *Manik Bajaj*[a], *Tamanna Bhagat*[b], *Rohit Raina*[b], *Gourav Kaushal*[c]

[a] *Department of Radiodiagnosis, All India Institute of Medical Sciences, Bathinda, Punjab 151001, India*
[b] *Department of General Medicine, All India Institute of Medical Sciences, Bathinda, Punjab 151001, India*
[c] *Department of Surgical Gastroenterology, All India Institute of Medical Sciences, Bathinda, Punjab 151001, India*

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ABSTRACT

Pseudoaneurysms of the splenic artery usually arise as a complication of pancreatitis. Due to the risk of rupture, treatment of the pseudoaneurysms of splenic artery is considered as a priority in the management of pancreatitis. While endovascular embolization is an established minimally invasive and effective technique for the treatment of splenic artery pseudoaneurysms, however, in some cases endovascular embolization may not be feasible, owing to the difficulties in accessing the distal small pseudoaneurysms or due to financial constraints. In such a scenario, percutaneous image guided direct puncture and embolization of the pseudoaneurysms is a valuable option. While most of the previous publications have reported on the use of n–butyl cyanoacrylate, coils and thrombin for percutaneous embolization of splenic artery pseudoaneurysms, however, these agents may not be easily accessible to many health facilities in emergency situations and their cost may limit their use. In this report, we describe a novel technique of percutaneous embolization of splenic artery pseudoaneurysms with **S**equential **A**spiration and injection of a **M**ixture of gelatin-based hemostatic agent and autologous blood clot followed by suture coiling for **E**ffective **E**mbolization of splenic artery pseudoaneurysm by interventional **R**adiologist (SAMEER technique). We demonstrate the safety and efficacy of this technique in a series of 2 cases.

☆ Competing Interests: The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

* Corresponding author.
E-mail address: sameer.peer602@gmail.com (S. Peer).

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Introduction

Splenic artery is the most commonly affected visceral artery and is ranked as the third most common intra-abdominal artery to be affected by aneurysmal pathology [1]. Most of the cases of splenic artery pseudoaneurysms are associated with pancreatitis [2]. In the clinical scenario of acute pancreatitis, enzymatic degeneration of the wall of the splenic artery by the inflammatory process or associated complications, such as walled-off pancreatic necrosis, predispose to the development of pseudoaneurysms of the splenic artery, which has a close anatomical proximity to the pancreas [2]. Since pseudoaneurysms lack a well-defined wall, they are predisposed to rupture and may lead to hypotension and shock [3]. In rare cases, the pseudoaneurysms may rupture into the pancreatic duct to cause upper gastrointestinal hemorrhage, a condition referred to as *Hemosuccus pancreaticus* [4]. Conventionally, the splenic artery pseudoaneurysms have been managed with open surgical or laproscopic approaches [5]. However, an acute inflammatory process associated with acute pancreatitis, could pose technical difficulties in reaching upto the site of the pseudoaneurysm and may lead to failure of treatment or additional complications [5]. In sub-acute to chronic stages, fibrotic changes in the pancreatic bed may also preclude successful surgical management of pseudoaneurysms [6]. Recently, endovascular approach has been advocated as a safe method of treatment of splenic artery pseudoaneurysms . Endovascular coil embolization or embolization with liquid embolic agents have been shown to be safe and effective in obliteration of the splenic artery pseudoaneurysms [7]. However, in many cases, endovascular approach to splenic artery may not be feasible, largely due to difficulties in access to the pseudoaneurysm as splenic artery may exhibit tortuous course and may pose difficulties in reaching the pseudoaneurysms of the distal branches of the splenic artery. In such cases, percutaneous direct embolization of the pseudoaneurysm has been shown to be a safe alternative treatment [8]. While previous cases of percutaneous direct embolization of splenic artery pseudoaneurysms have been carried out with various embolic agents such as thrombin and n–butyl cyanoacrylate glue, we describe a novel and cost effective technique of direct percutaneous embolization of splenic artery pseudoaneurysms in the clinical context of acute pancreatitis using gelatin-based hemostatic agent and autologous blood clot mixture, followed by coiling the aneurysm sac with nylon sutures to effectively embolize the pseudoaneurysm sac. This technique is termed as **S**equential **A**spiration and injection of a **M**ixture of gelatin-based hemostatic agent and autologous blood clot followed by suture coiling for **E**ffective **E**mbolization of splenic artery pseudoaneurysm by interventional **R**adiologist technique (Acronymized as: SAMEER technique).

Case report

We hereby describe the SAMEER technique with the help of a series of 2 cases of acute pancreatitis complicated by splenic artery pseudoaneurysm arising from the distal (splenic hilar) splenic artery branch. In both the cases, the tortuous course of the splenic artery and location of the pseudoaneurysm were considered as a potential source of difficulty and failure of endovascular embolization of the pseudoaneurysms. Also, considering the resource poor condition of the respective families, in both the cases, a novel technique was needed to tide over the emergent health condition of ruptured splenic artery pseudoaneurysms.

Table 1 – List of materials required for SAMEER technique.

Serial No.	Material
1.	18 G puncture needle
2.	Gelatin-based hemostatic agent
3.	10 mL Leur lock syringes
4.	3-way stop cock
5.	Normal saline (100 mL)
6.	2-0 Nylon sutures
7.	Iodinated contrast agent

Description of the SAMEER technique

The basic tenet of the SAMEER technique is to puncture the sac of the pseudoaneurysm using an 18 G puncture needle under imaging guidance. The modality used to puncture the sac of the pseudoaneurysm depends on how well the pseudoaneurysm is visualized on that particular modality. In this regard, ultrasound or CT may be used to puncture the pseudoaneurysm. Care must be taken to puncture the pseudoaneurysm in a single attempt as multiple attempts may lead to intra-procedural rupture of the pseudoaneurysm. The materials required for the technique are summarized in Table 1.

The steps of the SAMEER technique are as follows.

1. Identify the dome of the pseudoaneurysm using the imaging modality chosen by the operator.
2. Using imaging guidance, puncture the pseudoaneurysm with 18 G puncture needle
3. Once the position of the needle is confirmed within the sac of the pseudoaneurysm, free back flow of arterial blood is obtained.
4. Aspirate approximately 5 mL of arterial blood into a 10 mL leur lock syringe and allow the blood in the syringe to partially clot. While the blood is allowed to clot in the syringe, the hub of the puncture needle is occluded to avoid blood loss.
5. While the blood is allowed to form a coagulum, a slurry of hemostatic gelatin-based agent with normal saline and iodinated contrast mixture is prepared, to make a volume of about 5 mL. The slurry is made in a standard manner by cutting the gelatin-based hemostatic agent into small pieces and placing the pieces in a 10 mL leur lock syringe and vigorously mixing this with 5 mL of normal saline and iodinated contrast solution in another syringe, while connecting the 2 syringes to a 3-way stop cock and agitating the mixture for about 50-60 passes to make a semi-solid slurry.
6. In approximately 5-10 minutes, once the withdrawn blood in the syringe is in a semi-solid state, using a 3-way stopcock, the syringes containing the autologous blood clot and

hemostatic gelatin-based slurry are connected and vigorously agitated for another 50-60 passes to prepare a stable mixture.

7. This mixture of hemostatic-gelatin based slurry, normal saline, iodinated contrast and autologous blood clot is then injected into the aneurysm sac slowly. Initially, 5 mL of the mixture is injected. The distribution of the mixture is checked with ultrasound or CT.
8. The stasis of blood in the aneurysm sac is monitored with an ultrasound doppler or by CT or by the stoppage of the backflow of blood from the needle hub.
9. While the needle is still in place, 2-0 nylon suture is introduced into the aneurysm sac. The sutures are introduced till the point resistance to passage is felt and at that point the suture is cut at the needle hub and a stylet is used to push the last strand into the aneurysm sac.
10. Once stasis of blood in the pseudoaneurysm is confirmed, the needle is withdrawn while injecting small volume of the remaining mixture of gelatin-based hemostatic slurry and autologous blood clot to seal the needle puncture tract.
11. The puncture site is monitored for any active hemorrhage and sterile dressing is applied at the puncture site.

Case 1

A 49-year-old man, already diagnosed with severe acute pancreatitis about a week back, now presented with profuse sweating and giddiness while trying to get up from the bed. His general look was that of profound pallor and his extremities were cold and clammy on initial examination. His pulse rate was 120 beats per minute with a noninvasive blood pressure recorded at 80/50 mmHg. His lab investigations were remarkable for a hemoglobin level of 5 g/dL, which showed a drastic drop from a previous recorded hemoglobin level of 10 g/dL. There was no history of bleeding from natural orifices. His abdomen was tender in the epigastric region, however, no new finding on abdominal examination was noted as compared to his previous records. With the clinical picture suggesting hypovolemic shock, immediate resuscitation was started, and 2 units of packed red blood cells were transfused. While the resuscitation was being carried out, a triple phase abdominal CT scan was done with the strong suspicion of a potential intra-abdominal hemorrhage. Contrast enhanced CT scan (Fig. 1) sowed a large pseudoaneurysm of size $\sim 7.3 \times 5.8 \times 5.2$ cm in the lesser sac, which appeared partially thrombosed. A part of the pseudoaneurysm towards the splenic hilum showed patent lumen of size $\sim 4.5 \times 3.8 \times 3.2$ cm. The neck of the pseudoaneurysm was noted in relation to one of the distal hilar branches of the splenic artery. In view of the location of the aneurysm, the clinical condition of the patient and the financial considerations, it was decided to proceed with percutaneous direct embolization of the pseudoaneurysm. The procedural steps were carried out as per SAMEER technique under doppler ultrasound guidance (Fig. 2), and complete hemostasis within the aneurysm sac was noted after a procedure time of $\sim$ 20 minutes. The patient improved clinically with resuscitation measures and did not receive any further blood transfusions. The aneurysm showed complete occlusion and no signs of recanalization at a follow-up doppler ultrasound at 3 weeks (Fig. 2). His hemoglobin level was recorded at 9.4 g/dL and vitals were stable at 3 weeks follow-up after embolization.

Case 2

A 51-year-old man, a chronic alcoholic and smoker, presented with severe acute pain in the epigastric region of the abdomen and radiating to the back associated with multiple episodes of vomiting. The patient was clinically diagnosed with acute pancreatitis and the diagnosis was confirmed with a laboratory parameter suggesting serum amylase level of 1224 U/L (Normal range 30-110 U/L) and serum lipase level of 577 U/L (Normal range 0 –160 U/L). While receiving treatment in the hospital, the patient complained of malena and had a precipitous fall in blood pressure which was recorded as having dropped from 130/80 mmHg to 90/50 mmHg. The hemoglobin level also recorded a drop from 9 g/dL to 6.4 g/dL. Immediate resuscitation measures were initiated including transfusion of 2 units of packed red blood cells. Triple phase contrast enhanced CT scan of the abdomen (Fig. 3) revealed a fluid collection of size $\sim 8.2 \times 6.5 \times 3.8$ cm, in relation to the tail of pancreas, extending to the peri–splenic region. Within the wall of the collection, a pseudoaneurysm of size $\sim 2.2 \times 1.7 \times 1.5$ cm, arising from the distal splenic hilar branch of the splenic artery was noted (Fig. 3). The contents of the collection were found to be hyperdense on noncontrast CT, suggesting hemorrhage within the collection, likely from the rupture of the pseudoaneurysm. The patient underwent drainage of the peri–splenic collection with 14F pigtail catheter drain, which revealed hemorrhagic drain output. Considering the location of the pseudoaneurysm and the potential risk of failure of endovascular embolization and the financial considerations, it was decided to proceed with percutaneous direct embolization of the pseudoaneurysm. Since the pseudoaneurysm was small, it was difficult to visualize on doppler ultrasound. Hence, it was decided to use CT guidance for carrying out the procedure. CT guided percutaneous direct embolization (Fig. 4) was done using the SAMEER technique and complete stasis was noted within the sac at the end of the embolization. Following the embolization procedure, the general condition of the patient improved, and his vitals became stable. There were no further blood transfusions required, and the hemoglobin level stabilized at 8.4 g/dl. Follow-up CT scan (Fig. 5) at 2 weeks after embolization revealed no recurrence or recanalization of the pseudoaneurysm. The drain out-put in pigtail catheter gradually decreased to $\sim$ 10 mL of serous fluid per 24 hours and the drain was subsequently removed after 6 weeks.

Discussion

Percutaneous embolization of visceral pseudoaneurysms is a recent addition in the armamentarium of the interventional radiologists for the management of this life-threatening emergent condition. In a retrospective study including 80 patients with pancreatitis related visceral artery pseudoaneurysms, Gorsi et al., reported percutaneous transabdominal embolization of 15 pseudoaneurysms, out of which 7 received throm-

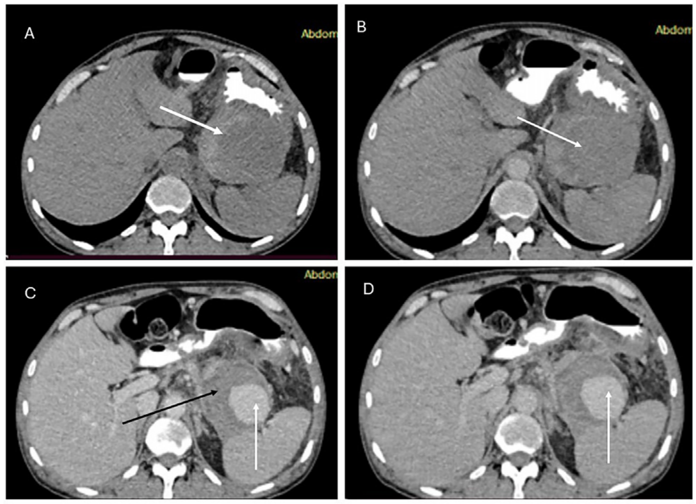

Fig. 1 – Case1. CT scan of the abdomen. The figure shows the axial CT scan of the abdomen at the level of the splenic hilum with noncontrast (A), arterial phase (B), venous phase (C) and delayed [5 minutes postcontrast] phase scans. There is progressive filling of the patent part of the pseudoaneurysm near the splenic hilum (white arrow in A, B, C and D). Note the partially thrombosed part of the pseudoaneurysm (black arrow in C).

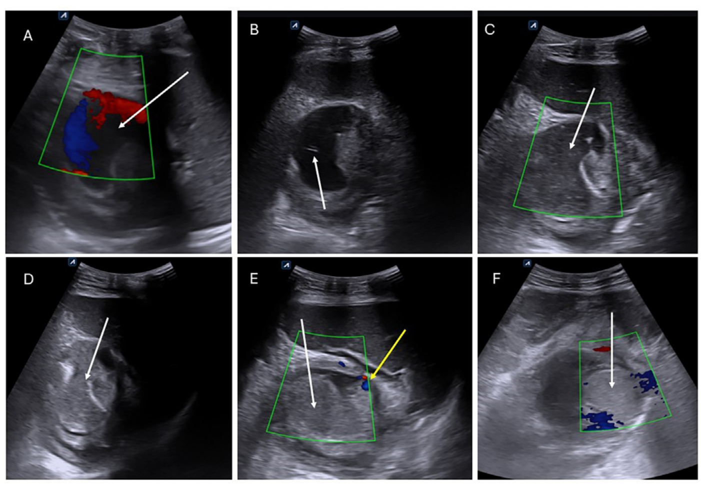

Fig. 2 – Case 1. Ultrasound guided percutaneous direct embolization of the pseudoaneurysm using the SAMEER technique. (A) Duplex scan of the pseudoaneurysm shows "ying-yang" flow within the pseudoaneuysm (white arrow). (B) Percutaneous puncture of the pseudoaneurysm with 18 G needle (white arrow). (C) Injection of a mixture of gelatin-based hemostatic foam slurry with autologous blood clot renders the lumen of the pseudoaneurysm echogenic(white arrow). (D) After an interval of 20 minutes, complete stasis of blood noted in the lumen of the pseudoaneurysm, and the lumen shows progressive increase in the echogenicity (white arrow) (E) Duplex ultrasound after placement of nylon suture coils within the sac of the shows complete thrombosis of the sac (white arrow). Note that the blood flow in the main splenic artery is still patent (yellow arrow) (F) Follow-up ultrasound doppler scan of the pseudoaneurysm shows complete persistent stable occlusion of the pseudoaneurysm (white arrow).

bin injection and 8 received n–butyl cyanoacrylate glue embolization [9]. While all patients with glue embolization attained successful closure of the pseudoaneurysm, only 4 patients with thrombin injection attained complete aneurysmal closure. Chen et al., reported a case of splenic artery aneurysm in a 53-year-old woman, which was successfully occluded with percutaneous direct ultrasoundguided injection of 1500 U of thrombin into the aneurysm sac as endovascular approach was deemed unsuitable and likely to fail [10]. Shrivastava et al., reported successful percutaneous embolization of splenic artery pseudoaneurysm in a case of chronic calcific atrophic pancreatitis. They used metallic coils as embolizing agents and demonstrated successful embolization of the pseudoaneurysm [11]. Huang et al., described a case of giant splenic artery pseudoaneurysm which was successfully managed with ultrasound guided direct puncture and em-

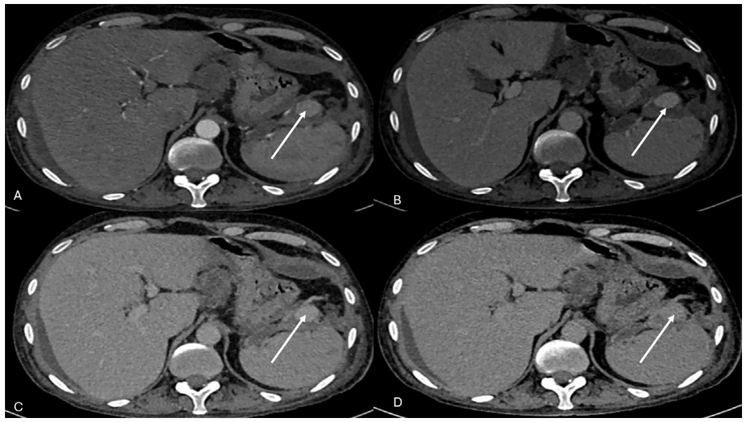

Fig. 3 – Case 2. CT scan of the abdomen. Axial Contrast enhanced CT scan of the abdomen at the level of the splenic hilum with arterial phase (A), portal phase (B), venous phase (C) and delayed [5 minutes postcontrast] phase. A well-defined pseudoaneurysm is noted in the distal splenic artery adjacent to the splenic hilum with progressive filling of contrast (white arrow in A,B and C) and persistence of contrast in delayed phase (white arrow in D).

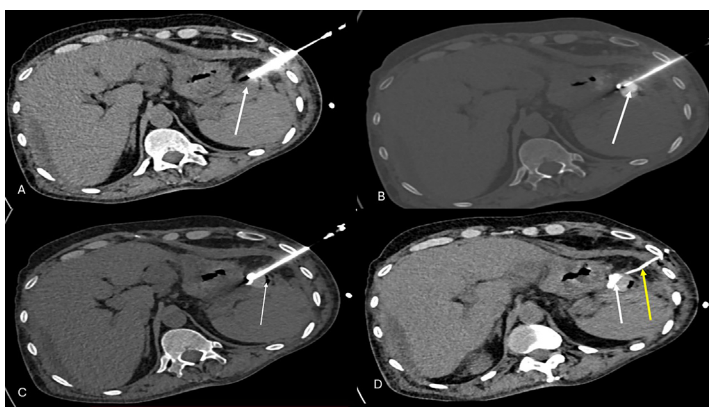

Fig. 4 – Case 2. Percutaneous CT guided embolization of the pseudoaneurysm with SAMEER technique
(A) The pseudoaneurysm sac (white arrow) is punctured with an 18G puncture needle with CT guidance.
(B) Axial CT image at the level of the pseudoaneurysm obtained after injection of the mixture of gelatin-based hemostatic foam slurry and autologous blood clot. Note that the sac of the pseudoaneurysm is filled by the embolysate (white arrow).
(C) Axial CT image at the level of the pseudoaneurysm after deployment of 2-0 nylon suture "coil". Note is made of some air trapped within the pseudoaneurysm sac (white arrow) during embolization. (D) Check CT scan obtained after emolization shows stasis of the embolysate within the aneurysm sac (white arrow). Also noted is the embosylate deposited along the tract of percutaneous needle insertion (yellow arrow).

bolization with a total of 15 mL of thrombin-collagen hemostatic agent (40 mg/mL of collagen and 1000 U/mL of thrombin) [12]. Endoscopic ultrasound guided thrombin injection has also been demonstrated to successfully occlude splenic artery pseudoaneurysm [13].

In the present series of 2 cases, we have described successful embolization of acute pancreatitis related pseudoaneurysms of the distal splenic artery using the SAMEER technique. This technique has a basic difference as compared with the cases reported thus far in the literature, in the type of embolizing agent used. This technique offers a cost-effective alternative to the existing embolizing agents, such as n–butyl cyanoacrylate, thrombin and metallic coils. These embolizing agents are also limited by their availability, in addition to the cost. Also, n–butyl cyanoacrylate injection requires expertise in preparation and injection and may lead to unwanted and severe complications such as nontarget embolization, and an exothermic reaction while undergoing polymerization which may lead to pain and tissue damage [14]. Hemostatic gelatin-based foam has been used as a temporary embolizing agent in the field of interventional radiology [15]. Although, it is a temporary embolizing agent, however, in life-threatening and emergent conditions, it is an easily available embolizing agent which may be used [15]. Autologus blood clot is also a safe embolizing agent and can be prepared without any special techniques while performing the intervention. Autologus blood clot initiates the coagulation cascade within the aneurysmal sac and promotes thrombosis of the pseudoaneurysm sac [16].

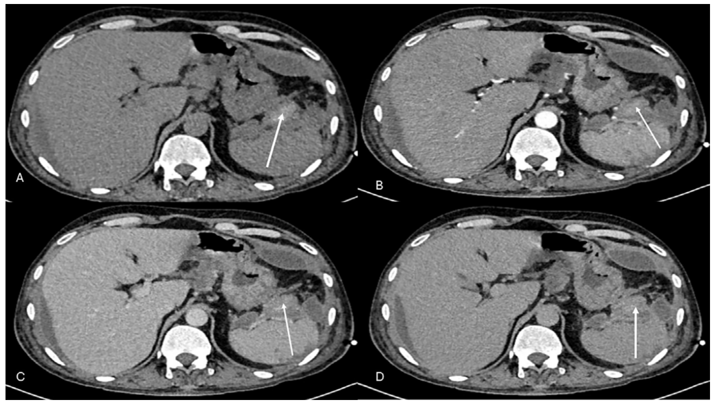

Fig. 5 – Case 2. CT scan of the abdomen at follow-up after 2 weeks of embolization. Contrast enhanced CT scan of the abdomen at the level corresponding to the pre-embolization scan with noncontrast (A), arterial (B), venous (C) and delayed [5 minutes postcontrast] phases. The site of the pseudoaneurysm appears hyperdense on noncontrast CT (white arrow in A). There is no contrast opacification of the pseudoaneurysm sac on subsequent multiphase acquisition (white arrows in B, C and D), thus confirming stable and persistent occlusion of the pseudoaneurysm sac.

While used alone, autologous blood clot may undergo lysis due to concomitant thrombolytic cascade within the body, however, in combination with other agents, the clot may become more stable [17]. Once the clot within the aneurysm sac stabalizes, over a period of days to weeks, the aneurysmal neck heals and the occlusion of the pseudoaneurysm sac may achieve a long-term success.

The purpose of additionally using nylon sutures within the pseudoaneurysm sac as a coil is to stabilize the clot within the pseudoaneurysm sac. Nylon sutures are commonly used in surgical practice and have been shown to promote thrombosis [18]. Addition of nylon to metallic coils has been shown to accelerate the aneurysm occlusion rates of the fibred coils [19]. Vidal et al., have proposed the concept known as the FAIR-embo concept, whereby, suture materials are used as embolization agents, thus envisaging the wider availability of therapeutic arterial embolizations to resource poor conditions [20]. In vivo studies by Di Bisceglie et al. and Banata Gang-Ny et al. have also carried forward the feasibility of the FAIR-embo concept [21,22]. Thus, the use of nylon sutures as coils within the aneurysm sac could lead to stable thrombosis within the pseudoaneurysm sac and potential long-term benefit.

There are limitations to the SAMEER technique, which may be worked upon and lead to further research. One is that the nylon sutures are nonradiopaque, hence direct visualization of the behavior of the sutures while coiling within the pseudoaneurysm sac cannot be precisely controlled. Even on ultrasound, these sutures are not seen entirely. Future research may focus on rendering the sutures radiopaque or use of radiopaque material as microcoils for direct percutaneous embolization. Another limitation is the control of the flow at the neck of the pseudoaneurysm. The lack of control at the neck of the pseudoaneurysm could potentially lead to nontarget distal bed embolization, which may lead to splenic infarcts. Although in this series, both the patients did not suffer splenic infarction, however, this remains a potential pitfall of this technique. Particularly, if aneurysms arise form a larger artery or have a wide neck, nontarget parent artery occlusion is a threat. In this scenario, a combination of percutaneous embolization with coverage of the neck of the pseudoaneurysm with a device, such as a balloon, may be desirable before proceeding with the SAMEER technique. However, it is to be noted that parent artery occlusion and distal nontarget embolization may be seen as potential complications of the already established techniques, including endovascular embolization, and may not be specific to the technique described here [23]. Another potential limitation is in patients on anticoagulants or antiplatelets or with coagulopathy, whether thrombosis of the sac of the pseudoaneurysm may not be possible with SAMEER technique. Also, the total volume of the embosylate and the number of suture coils to be deployed within the aneurysm sac may vary with the size of the aneurysm and needs to be evaluated on case-to-case basis.

Conclusion

SAMEER technique is a safe and feasible approach for percutaneous direct image-guided embolization of distally located splenic artery pseudoaneurysms arising in the clinical scenario of acute pancreatitis, where endovascular approach may fail or is considered unsuitable. Further research to address the limitations of the technique may help in its application in a wider range of aneurysms and pseudoaneurysms, particularly in resource poor and emergency situations where other embolic agents may not be easily available.

Declaration of generative AI and AI-assisted technologies in the writing process

The authors declare that none of the Generative AI and AI-assisted technologies were used while writing this manuscript.

Patient consent

An informed written consent was obtained from the next of kin of the patients for publication of patient related information and images.

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