5 Interventions in Pancreatitis: Management of Vascular Complications

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5.1 Introduction

The incidence of major vascular involvement in pancreatitis is 1.2–14 % with a higher frequency of involvement in chronic pancreatitis (7–10%) compared to acute pancreatitis (1–6%). Mortality in patients with bleeding from major vascular involvement has been reported to be between 34% to 52% [1]. Bleeding in pancreatitis is usually due to the direct involvement of a vessel (mostly causing pseudoaneurysm formation) resulting in rupture into gastrointestinal tract/pseudocyst/abscess cavity/pancreatic duct/peritoneal cavity/retroperitoneum. Bleeding can also occur from varices due to the portal or splenic or mesenteric vein thrombosis. Other causes of bleeding include peptic ulcer disease (more prevalent in pancreatitis patients than the general population), Mallory-Weiss tears, splenic infarction, and splenic rupture [1, 2].

The risk factors described for vascular complications are necrotizing type of pancreatitis, organ failure involving multiple organs, sepsis, and pancreatic or peripancreatic fluid collections, history of necrosectomy, vasculitis, and patients on anticoagulants [3]. In a study by Bergert et al., major bleeding was due to pseudoaneurysm in 69.4% cases, peptic ulcers or varices in 22.2%, and splenic infarction or rupture in 8.4% cases [2].

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5.2 Pathophysiology

Several pathogenic mechanisms are involved in the development of vascular complications. One is due to the adjacent extension of the inflammatory process, ischemic necrosis, and exocrine enzymes of the pancreas. If abscesses develop weeks to months later during the course of pancreatitis, associated infective organism also contributes to the vascular injury.

Pseudocysts can result in vascular injury due to compression, and elastolytic enzymes from their walls. Venous involvement is also due to the similar pathogenic mechanisms resulting in sinistral portal hypertension. Iatrogenic causes include surgery (necrosectomy) and percutaneous drain insertion due to direct vascular injury or mechanical irritation [1, 4]. Boudghene et al. reported the source of arterial bleeding as splenic artery in 42.4% cases, gastroduodenal artery (GDA) in 21.7%, pancreaticoduodenal arteries in 25.5%, hepatic artery and superior mesenteric artery (SMA) in 2.8% each, jejunal arteries in 1.9%, other intestinal arteries and renal arteries in 0.9% each [5].

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5.3 Vascular Anatomy and Anastomotic Pathways

The various branches of celiac and superior mesenteric arteries supplying the pancreas are depicted in Fig. 5.1. Various anastomotic pathways described are between superior and inferior pancreaticoduodenal arteries, between DPA and SPDAs, between DPA, TPA, and GPA, between caudal pancreatic arteries and TPA, GPA. Arc of Buhler is the persistent embryonic connection between the celiac artery and SMA independent of GDA and DPA. Arc of Barkow is formed by communication between the right and left gastroepiploic arteries [6–8]. Knowledge of these anastomoses is important for effective endovascular treatment and to prevent recanalization of the pseudoaneurysm.

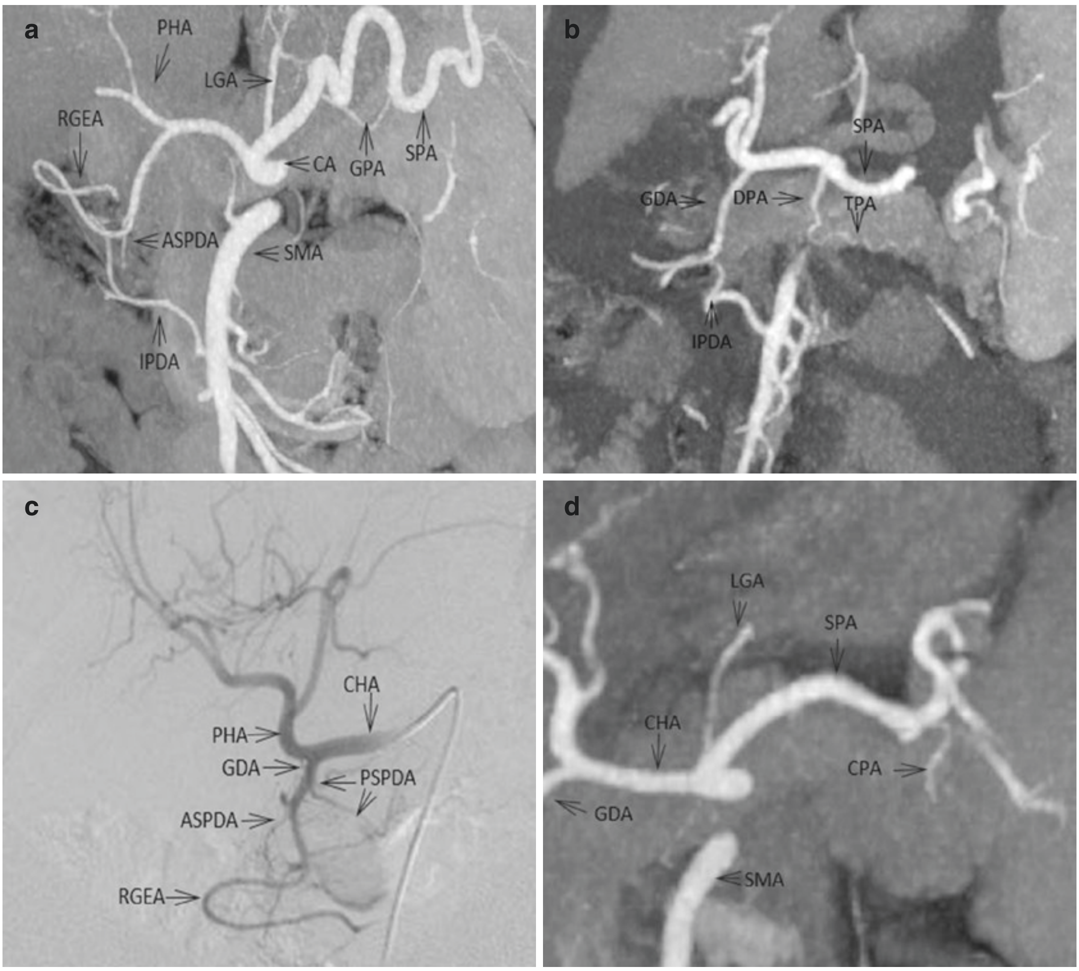


Fig. 5.1 Arterial supply to the pancreas: Maximum Intensity Projections of CT Angiography in coronal oblique plane (**a**, **b** and **d**) and selective digital subtraction angiogram of common hepatic artery (**c**) showing arterial supply to pancreas. Anterior superior pancreaticoduodenal artery (ASPDA), Caudal pancreatic arteries (CPA), Celiac artery (CA), Common hepatic artery (CHA), Dorsal pancreatic artery (DPA), Gastroduodenal artery (GDA), Great pancreatic artery (GPA), Inferior pancreaticoduodenal artery (IPDA), Left gastric artery (LGA), Posterior superior pancreaticoduodenal artery (PSPDA), Proper hepatic artery (PHA), Right gastroepiploic artery (RGEA), Splenic artery (SPA), Superior mesenteric artery (SMA), Transverse pancreatic artery (TPA)

5.4 Clinical Features

Bleeding in pancreatitis can be gastrointestinal (GI) bleed or non-gastrointestinal bleed. GI bleed presents as hematemesis, melena, or rarely haematochezia. Non-GI bleed presents as abdominal pain or hemorrhagic shock. Most of these patients have a drop in hemoglobin of at least 2–3 gm/dl. Some of the pseudoaneurysms may be incidentally detected on imaging [3]. The role of imaging modalities is described in Table 5.1.

5.5 Treatment Approach to Vascular Complications of Pancreatitis

Most authors advise treatment of all the pseudoaneurysms detected at the earliest as the mortality rates of their rupture can be up to 100%. There are no guidelines for the timing of treatment in pseudoaneurysms. However, regarding the choice of treatment, the International Association of Pancreatology/American Pancreatic Association guidelines for acute pancreatitis and United European Gastroenterology guidelines for chronic pancreatitis recommend endovascular treatment as the initial choice of treatment for pseudoaneurysms [9, 10].

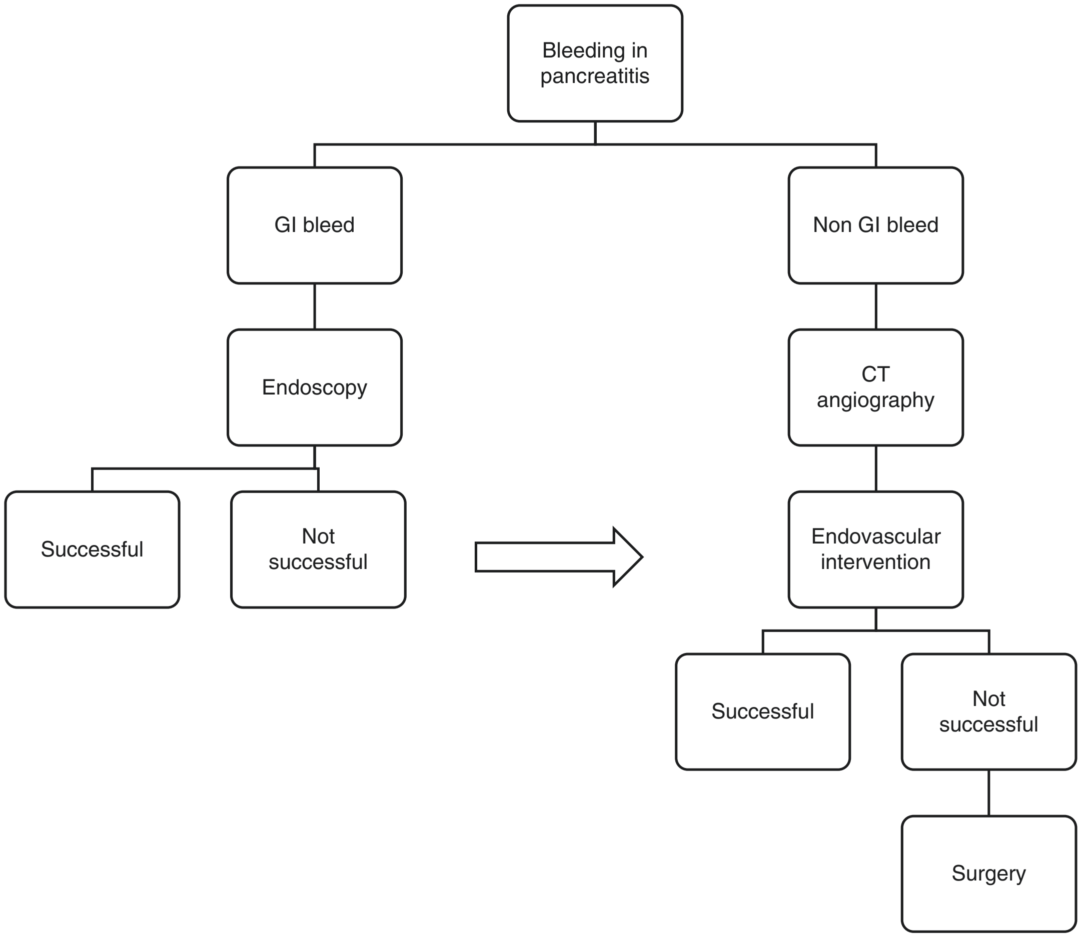
Bergert et al and Balachandra et al reported higher mortality rates in surgery first approach compared to endovascular first approach [2, 11]. Hemorrhagic shock and the number of units of blood transfused (>10) were found to be significant predictors of mortality. The endovascular approach required fewer units of blood and shorter hospital stay [2, 12]. The algorithm proposed by various authors for the management of bleeding in pancreatitis is given in Flowchart 5.1 [2, 3, 13]. Hardware required for endovascular intervention is described in Table 5.2.

5.6 Endovascular Therapy of Pseudoaneurysms/Arterial Bleeding in Pancreatitis

Standard pre-procedural preparation and contraindications for catheter-directed angiography are also applied here [14]. The femoral arterial access is the preferred route with brachial or axillary approach reserved for those with acute-angled origins of feeders from the aorta. Angled catheters like MPA are used for cannulating the arteries arising from the aorta with an angle of origin between 0 to 60 degrees and curved catheters like Cobra 2 are used if the angle is

Table 5.1 Role of different imaging modalities in vascular complications of pancreatitis

Ultrasound	CT angiography	DSA angiography
Advantages • Can be done on bedside • Easily available • Cheaper • No radiation exposure • Contrast enhanced ultrasound can be useful in patients where iodinated contrast cannot be used *Disadvantages* • Operator dependant • Meteorism and obesity can obscure visibility	Most commonly used investigation for diagnosis *Advantages* • Not operator dependant • Fast • Highly accurate • Shows extraluminal features of pseudoaneurysm • MIP, 3D, and VR reformats helpful before intervention for planning *Disadvantages* • Radiation exposure • Contrast cannot be used in allergic or renal compromise patients	Gold standard investigation *Advantages* • Real-time evaluation of collateral supply to assess the expendability of artery • Treatment can also be done during angiography • Most sensitive to detect active bleeding and small pseudoaneurysms *Disadvantages* • Apart from sharing the disadvantages of CT angiography, there are other risks of this invasive modality discussed in complications section of this chapter



Flowchart 5.1 Approach to management of bleeding in pancreatitis

Table 5.2 Hardware required for endovascular management of vascular complications in pancreatitis

1. 18G puncture needle
2. Micropuncture set 4F
3. Arterial sheath (5F or 6F, 11 cm for initial access and other sizes and lengths depending on the stent size and vessel). E.g., Super ArrowFlex® (Teleflex): 5F–11F, 11–90 cm, Destination® (Terumo): 5F–8F, 45–90 cm, Performer™ Guiding sheath (Cook Medical): 5F–16F, 48–85 cm.
4. Hydrophilic guidewire. E.g., Glidewire® (Terumo): 0.035″–150 cm, 260 cm, angled tip
5. Stiff guidewire. E.g., Amplatz® (Cook Medical): 0.035″–150 cm, 260 cm
6. Diagnostic catheters. E.g., MPA, C2, SIM1, H1, Picard: 5F or 4F
7. Microcatheters. E.g., Progreat® coaxial (Terumo): 2.7F, 2.8F, Renegade™ (Boston Scientific)-2.4F-2.8F, Direxion™ (Boston Scientific): 2.4F, 2.8F.
8. Pushable coils-0018″ and 0.035″. E.g., MReye® (Cook Medical), Nester® (Cook Medical), VortX® (Boston Scientific)
9. Detachable coils. E.g., GDC® (Stryker), Target® (Stryker), Hydrocoil® (MicroVention)
10. Covered stent grafts. E.g., Fluency® Plus (BD Interventional): 6–13.5 mm, Graft master® (Abbott): 2.8–4.8 mm diameter.
11. Thrombin
12. Glue
13. Heparin
14. Nitroglycerin (used in case of vasospasm)

between 60 to 120 degrees and reverse curve catheters like Simmons 1 are used if the angle is greater than 120 degrees [15].

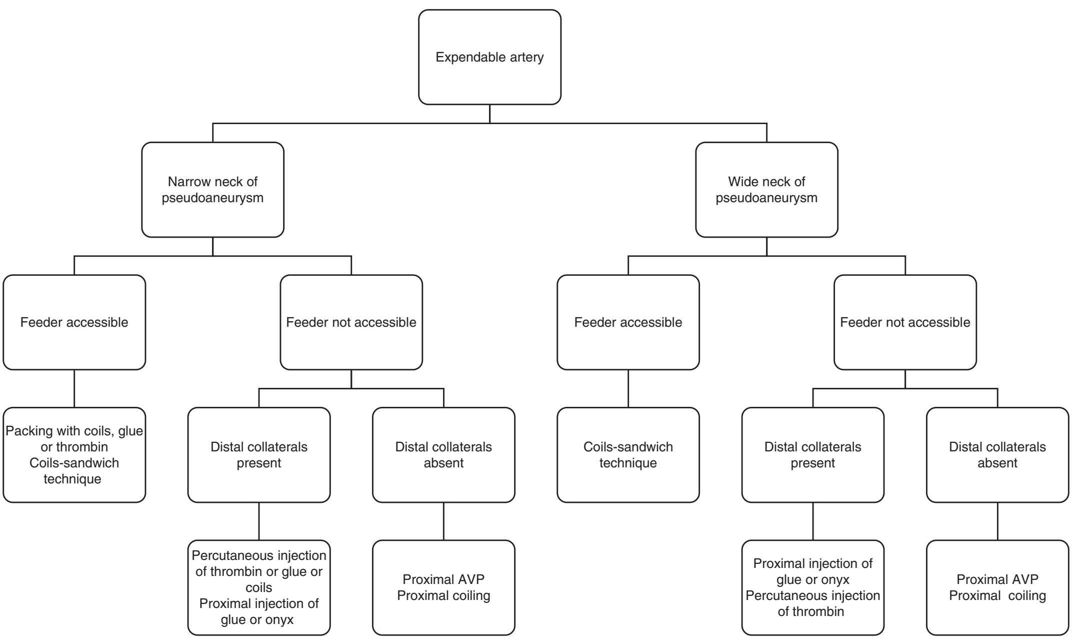
After diagnostic angiograms, the smaller feeding arteries can be selectively catheterized using microcatheters. Cannulating the left gastric artery can be difficult. Various techniques described are: forming Waltman loop, using a reverse curved catheter, side hole creation in the shepherd's hook catheter, and passing microcatheter through this side hole [16].

The choice of endovascular treatment depends on the expendability of the artery, tortuosity/angle of origin of the arteries. The expendable arteries are the splenic, gastroduodenal, and inferior pancreaticoduodenal arteries. SMA, intestinal arteries, celiac artery trifurcation (pseudoaneurysm arising from trifurcation) are considered as nonexpendable arteries. There are case reports in which proper hepatic artery was embolized if there is sufficient collateral circulation from SMA with patent portal vein. The proposed selection of treatment by various authors is given in Flowcharts 5.2 and 5.3 [17–19].

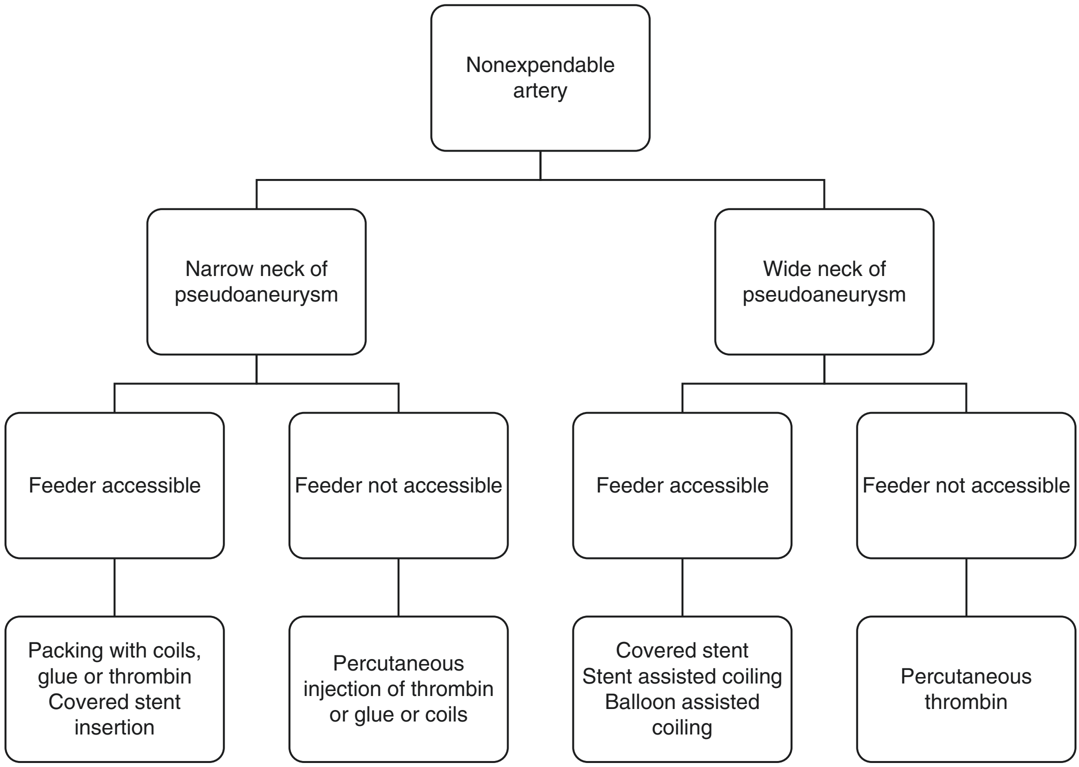
5.6.1 Embolization with Coils

This is the most commonly described technique for the endovascular management of pseudoaneurysms. If an expendable bleeding vessel could be selectively cannulated, then the coils can be placed on either side of the neck of pseudoaneurysm in distal to the proximal direction ("sandwich" technique). This is to prevent the revascularisation of the pseudoaneurysm by the collaterals (Figs. 5.2, 5.3, and 5.4). Twenty to thirty percent oversizing of coils is recommended relative to the vessel. In case of a nonexpendable bleeding vessel, if the pseudoaneurysm (with narrow neck) can be selectively cannulated, then detachable coils can be implanted directly. The detachable coils offer the advantage of precise placement and they can be withdrawn if not placed appropriately.

In case of a nonexpendable bleeding vessel with wide neck, coils cannot be directly placed into the pseudoaneurysm in this scenario, as there is a risk of coil migration into the parent artery (up to 3%). If the covered stent could not be



Flowchart 5.2 Approach to endovascular treatment in expendable artery



Flowchart 5.3 Approach to endovascular treatment in nonexpendable artery

placed due to tortuous anatomy or nonavailability, then stent-assisted coiling can be done. In this technique, an uncovered stent is placed across the pseudoaneurysm neck followed by the insertion of coils into the pseudoaneurysm through the interstices of the stent. Another technique is the "balloon-assisted remodeling" in which a balloon is inflated across the neck and a catheter is passed adjacent to inflated balloon into the pseudoaneurysm sac for coil packing [1, 19].

However, there are situations in which nonexpendable artery needs to be embolized proximally if the patient is hemodynamically unstable, unfit for surgery and the pseudoaneurysm cannot be accessed by endovascular or percutaneous or endoscopic ultrasound (EUS) route [1]. In patients with coagulopathy or shock adjuvant use of gelfoam or thrombin is needed for occlusion of the vessel [1, 20]. Technical success of 67% to 100% has been described in literature, rebleed in 5.7% to 17%, and complications in 0% to 17% [12, 21, 22]. Udd et al. reported decreased technical success for the embolization of splenic artery bleeders due to pseudocysts located in the body and tail of the pancreas [12].

5.6.2 Liquid Embolic Agents

Thrombin (bovine or human), an adhesive liquid embolic agent can be used by the endovascular route in a nonexpendable artery where covered stent insertion is not feasible or not affordable. This is also used for occlusion of pseudoaneurysms arising from the expendable artery if coil insertion is not feasible [18]. USG or CT guided percutaneous injection using 22G needle is also a described technique, if the neck is not accessible by the endovascular route. Some authors routinely use this technique for all the pseudoaneurysms [23]. The amount of thrombin injected depends upon the pseudoaneurysm cavity size and flow rate. Most authors used 1000 to 1500 IU during percutaneous injection [24]. Zabicki et al

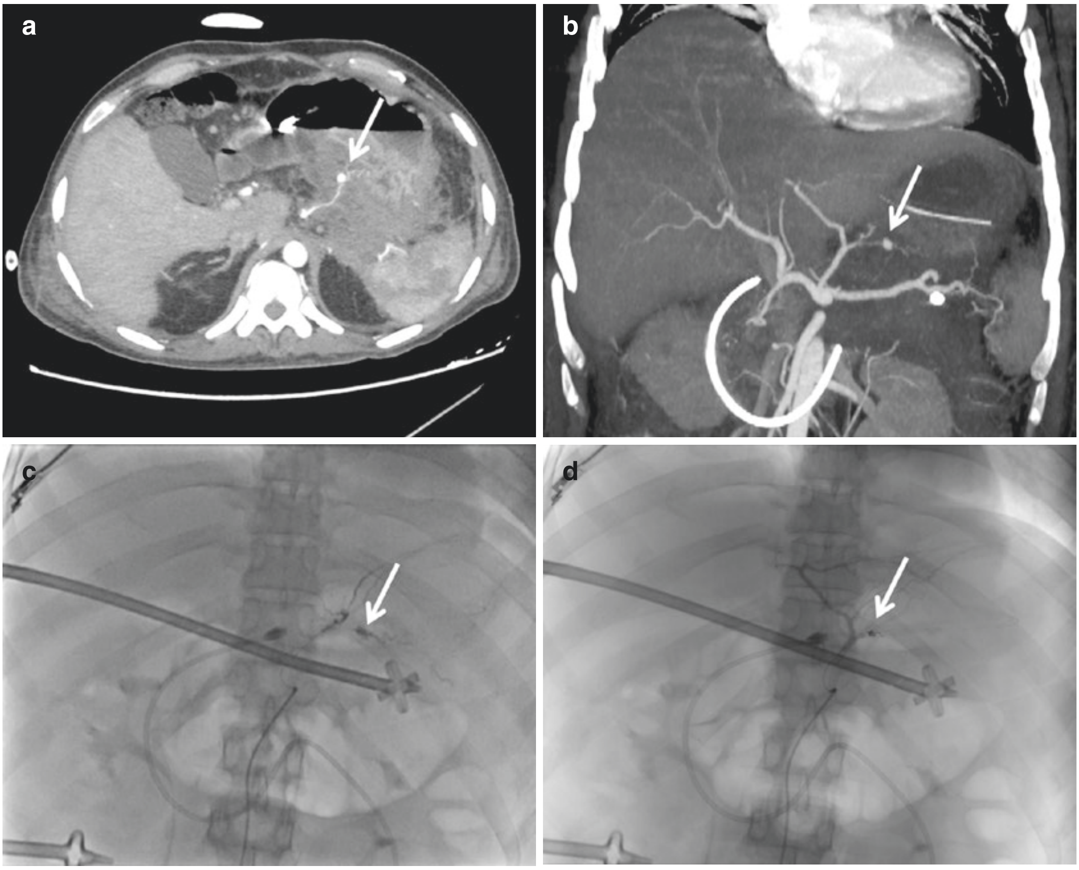


Fig. 5.2 38 years old male with acute pancreatitis and hemoglobin drop. (**a**) Axial CECT image showing pseudoaneurysm arising from the left gastric artery. (**b**) Oblique coronal MIP image shows pseudoaneurysm arising from the left gastric artery. (**c**) Selective angiogram showing pseudoaneurysm from the left gastric artery. (**d**) Coiling (arrow) of pseudoaneurysm was done and check angiogram shows no flow in the pseudoaneurysm

initiated endovascular injection with 400 IU for cavity diameter less than 2 cm and 800 IU for >2 cm cavities and adjusted the dose depending on the residual flow in the pseudoaneurysm [18].

Thrombin is not effective in pseudoaneurysms with high flow rate and in coagulopathic patients. In these situations, adjuvant insertion of coils is proposed by authors if the pseudoaneurysm neck is narrow. This adjuvant use of other embolizing agents is also recommended in critical situations where immediate occlusion is needed. Complications reported with the use of thrombin include parent artery occlusion, AV fistulas. Allergic reactions can be minimized with the use of human thrombin [18]. Among the case reports on visceral artery pseudoaneurysm embolization with thrombin, 100% technical success rate was reported, with adjuvant use of coils in only 5.3%. The rebleed rates were reported in up to 21% cases, so close surveillance for revascularisation is recommended [24].

Other liquid embolic agents like *onyx and glue (n Butyl Cyanoacrylate)* are injected when the bleeding vessel cannot be accessed. These are mostly used for expendable arteries [18]. However, some authors used glue injection for selective embolization of pseudoaneurysm in nonexpendable arteries [25]. These agents have the advantage of occluding all the downstream smaller branches, collaterals from the point of injection, and also the potential for occlusion in coagulopathic patients. The disadvantages include adherence of the embolising agent to catheter and embolization of non-target vessels in

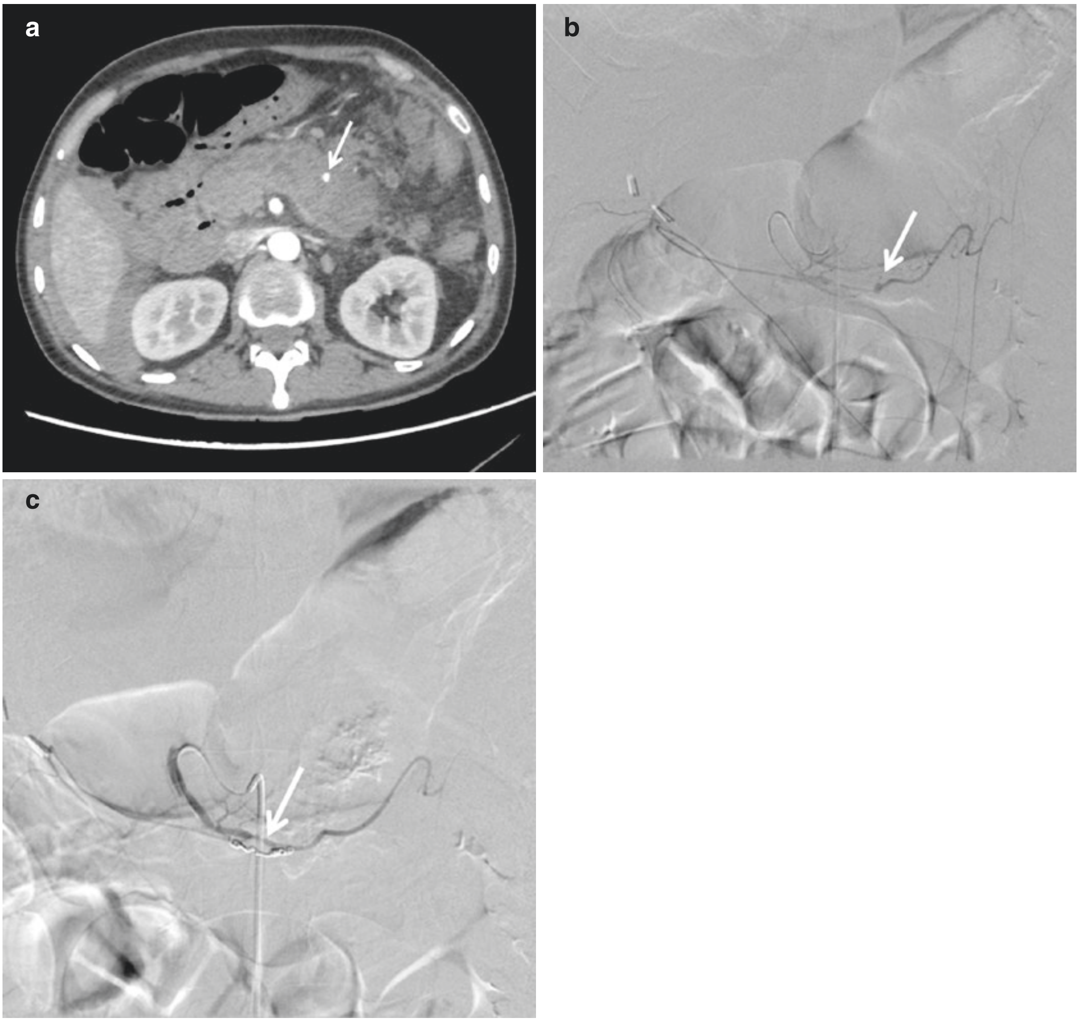


Fig. 5.3 30 years old male with acute pancreatitis and hemorrhagic shock. (**a**) Axial CECT shows arterial blush within the acute necrotising collection in the peripancreatic region. (**b**) Selective angiogram showing pseudoaneurysm from the right gastroepiploic artery. (**c**) Coiling of pseudoaneurysm was done and check angiogram shows no flow within the pseudoaneurysm

the hands of inexperienced interventionists [18]. Loffroy et al. advised against the use of glue in pseudoaneurysms arising from the proximal aspect of large nonexpendable arteries [26].

Lipiodol is mixed with glue to adjust the rate of polymerization. The amount of mixture injected at a time depends on the microcatheter dead space (usually 0.1–0.3 ml), size of parent artery, size of the pseudoaneurysm, and flow dynamics. Slower injection to prevent reflux, test injection with contrast, immediate withdrawal of microcatheter and residual glue aspiration through guiding catheter are recommended techniques to prevent complications. Madhusudhan et al proposed a "sequential injection flushing technique" to improve the safety of glue embolization. Microcatheter was flushed with 5% dextrose after glue injection. Recent studies on glue embolization reported technical success of 94% to 100%, rebleed in 0% to 15% and major complications in 0% to 25% [25, 27].

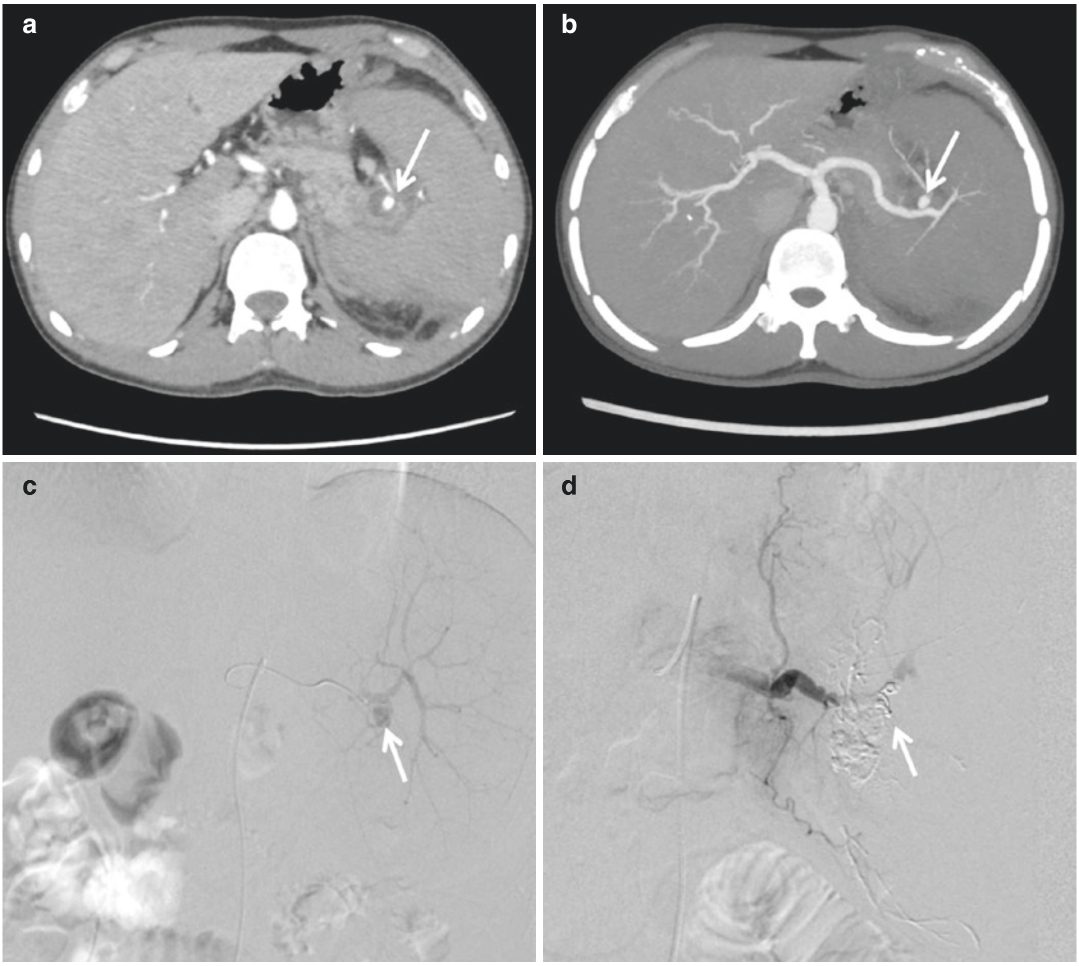


Fig. 5.4 Forty two years old female with chronic pancreatitis and asymptomatic. (**a**) Axial CECT shows small focal collection adjacent to tail of pancreas with arterial blush within. (**b**) Oblique axial MIP image shows pseudoaneurysm arising from splenic artery. (**c**) Selective angiogram showing pseudoaneurysm from splenic artery. (**d**) Coiling of pseudoaneurysm was done and check angiogram shows no flow within the pseudoaneurysm

5.6.3 Stents

Covered stent insertion is a commonly described technique for the treatment of pseudoaneurysms arising from a nonexpendable artery. These are mostly preferred in arteries with a straight course and a caliber ≥ 6 mm (e.g. SMA) [18]. However recent studies reported usage of flexible covered stents in tortuous visceral arteries (common hepatic artery, celiac trunk, gastroduodenal artery, splenic artery, and renal artery) with the technical success of 84.2% to 100% [28, 29]. Stent thrombosis is a potential complication particularly in those with smaller vessels, smokers, chronic diseases like diabetes mellitus. Occlusion of the branches arising from the parent artery is also a potential complication [18].

Flow diverter stents are the self-expandable, uncovered stents with multiple layers which modulate the flow leading to a decrease in the velocity and turbulence in the aneurysm/pseudoaneurysm leading to gradual thrombosis. If there is a side branch arising from the aneurysm/pseudoaneurysm, the flow will be preferentially directed to that side branch due to Venturi effect thereby preventing its occlusion.

These stents are used in many extra cranial nonexpendable arteries like hepatic artery, celiac trunk, SMA [19]. Ruffino et al reported a technical success rate of 100% and stent thrombosis of 11.1% at the end of 1 year [30]. Antiplatelet therapy is routinely prescribed after covered or flow diverter stent insertion. Clopidogrel (75 mg/day) for 4–6 weeks and lifelong aspirin (75–100 mg/day) are the drugs which are commonly prescribed [24, 28].

5.6.4 Amplatzer Vascular Plugs

Amplatzer vascular plugs are well suited for large caliber expendable vessels which do not have collaterals distally leading to revascularisation of the pseudoaneurysm. They have the advantages of faster, reliable embolization, accurate positioning, short landing zone, ability to retrieve and reposition if malpositioned. The requirement issues of larger sheaths and a straighter vessel are solved by the new generation AVPs. All manufacturers advise 30–50% oversizing of the AVP compared to the vessel [18]. In one study, there was technical success of 96% for gastroduodenal artery occlusion with AVP II and only one patient (4%) required additional coils placement [31]. However, Zhu et al. reported the use of additional embolization agents in 78% patients for occlusion of the proximal splenic artery [32].

5.7 Venous Complications in Pancreatitis

The role of interventional radiology is in two scenarios. One is in patients with bleeding from sinistral portal hypertension. If the patients are not fit for surgery (splenectomy), then partial splenic artery embolization can be performed in this scenario. Also, preoperative embolization can be done if the patient is fit for surgery to minimize bleeding during splenectomy. The other scenario is in the cavernous transformation of the portal vein with bleeding. If the bleeding is not controlled by endoscopy, TIPS can be performed if feasible [33].

5.8 Complications

Apart from puncture-related complications, the embolization procedure-related complications include pseudoaneurysm rupture, arterial dissection, and non-target embolization leading to organ ischemia. Pseudoaneurysm rupture during endovascular embolization is dealt with liquid embolic agents or gelfoam embolization. Rupture during percutaneous embolization requires emergent endovascular or surgical management. Flow limiting arterial dissection of a large proximal vessel is treated by heparin injection and balloon angioplasty/stent insertion. Splenectomy or bowel resection may be needed in patients with severe persistent symptoms due to organ ischemia. Complications after embolization include post embolization syndrome which is managed by symptomatic treatment and abscess formation in target organ which requires percutaneous drainage. Post-procedure vitals and hemoglobin monitoring are recommended for early detection of rebleed [1, 19].

5.9 Conclusion

Vascular complications are one of the significant causes of mortality in patients with pancreatitis. Careful evaluation, early detection, and multidisciplinary treatment approach can significantly reduce the mortality. Most of the guidelines recommend endovascular treatment as initial choice of treatment for non-gastrointestinal bleed. Assessing the bleeding vessel, pseudoaneurysm, collaterals, affordability, local availability of expertise, and hardware determine the choice of the endovascular technique.

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