Original Article

Visceral artery pseudoaneurysm: predictive factors for clinical success after transarterial embolization

Rémi Grange[1], Vincent Habouzit[2], Nicolas Stacoffe[3], Nicolas Magand[1], Nicolas Williet[4], Bertrand Le Roy[5], Claire Boutet[1], Sylvain Grange[1]

[1]Department of Radiology, University Hospital of Saint-Etienne, Saint-Etienne, France; [2]Departement of Nuclear Medicine, University Hospital of Saint-Etienne, Saint-Etienne, France; [3]Department of Radiology, University Hospital of Lyon, Lyon, France; [4]Department of Gastro-Enterology, University Hospital of Saint-Etienne, Saint-Etienne, France; [5]Department of Digestive and Oncologic Surgery, University Hospital of Saint-Etienne, Saint-Etienne, France

Contributions: (I) Conception and design: R Grange, S Grange; (II) Administrative support: R Grange, S Grange; (III) Provision of study materials or patients: R Grange, S Grange, B Le Roy, N Williet; (IV) Collection and assembly of data: R Grange, V Habouzit; (V) Data analysis and interpretation: R Grange, V Habouzit; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

Correspondence to: Rémi Grange, MD. Department of Radiology, University Hospital of Saint-Etienne, France Avenue Albert Raimond 42270 Saint-Priest-En-Jarez, Saint-Etienne, France. Email: remgrange1@gmail.com.

Background: Visceral artery pseudoaneurysm (VAPA) may result from trauma, operation, infection, inflammation, vasculitis, or malignancy. Factors associated with clinical success transarterial embolization (TAE) of VAPA have never been reported. The aim of this retrospective monocentric study was to describe clinical presentation and outcomes for patients treated for VAPA with TAE, and to identify factors associated with clinical success.

Methods: We retrospectively reviewed data from all patients referred to the University Hospital of Saint-Etienne treated with TAE for VAPA between October 2012 and January 2023. Inclusion criteria included: all patients treated by TAE for VAPA arising from branches of the coeliac trunk, superior mesenteric artery, and renal artery. We considered pre- and per-procedure clinical data, biological data, outcomes, and complications. Post-operative data included early mortality (≤30 days), repeat embolization, and complications. Predictive factors associated with clinical success were evaluated.

Results: Our sample included 89 patients (68 males). The median age was 65 [49–74] [median (Q1–Q3)] years, and the median hemoglobin level was 9 (7.6–11) g/dL. On pre-operative computed tomography (CT), active bleeding was detected in 31 (34.8%) patients. Coils were used in 58 (65.2%) procedures. Clinical success was achieved in 77 (86.5%) patients. There were 11 (12.4%) minor complications. Five (5.6%) patients died within the first 30 days. In univariate analysis, hemoglobin levels were associated with clinical success (P=0.027) and number of red blood cell (RBC) transfusions (P=0.007) and gastrointestinal bleedings (P=0.005) were associated with clinical failure. No factors were statistically significant in multivariate analysis.

Conclusions: Low hemoglobin levels, high numbers of RBC transfusions, and gastrointestinal bleedings were associated with clinical failure after TAE for VAPA. Multicentre studies are needed to investigate further.

Keywords: Embolization; aneurysm-false; hemorrhage

Submitted Mar 08, 2024. Accepted for publication Jun 27, 2024. Published online Aug 07, 2024.
doi: 10.21037/qims-24-463
View this article at: https://dx.doi.org/10.21037/qims-24-463

Introduction

Visceral artery pseudoaneurysm (VAPA) is defined as a disruption of the elastic fibres and smooth muscles of the tunica media, which is sometimes associated with interruption of the intima that arises from splanchnic circulation and the renal artery. VAPA may result from trauma, operation, infection, inflammation, vasculitis, or malignancy (1) . The clinical presentation varies between no clinical symptoms at all to acute, severe active bleeding leading to death. The prognosis depends on the cause of the VAPA, its location (2), and clinical presentation. All VAPA, even asymptomatic, require treatments due to high mortality related to ruptures, even if spontaneous thrombosis has been reported (3). There are various management options, including non-operative management (4), transarterial embolization (TAE), percutaneous embolization (5), endoscopic ultrasound embolization (6), and surgery. Historically, surgery has been the preferred treatment option, but TAE is becoming the first-line treatment due to its low periprocedural morbidity (7), the possibility of performing it under local anesthesia, and higher long-term survival (8). Percutaneous approaches have also been described to treat pseudoaneurysms as a first-line treatment (5) or after failure of endovascular treatments (9). However, this technique is valuable when the VAPA is close to the abdominal wall, particularly for patients with good echogenicity, which allows for good ultrasound visibility. Furthermore, this technique does not allow rapid occlusion of the artery that is feeding the pseudoaneurysm in case of rupture of the aneurysm sac.

Previous studies included single-centre retrospective studies with few patients, and they do not provide descriptions of clinical and biological severity (10-15). Moreover, to our knowledge, factors associated with clinical success following TAE of VAPA have never been reported.

The aim of this retrospective monocentric study was to evaluate factors associated with clinical success after TAE of VAPA. We present this article in accordance with the STROBE reporting checklist (available at https://qims.amegroups.com/article/view/10.21037/qims-24-463/rc).

Methods

Study population

We reviewed the data of all patients treated with TAE for VAPA in our institute between October 2012 and January 2023. We selected patients based upon clinical decisions following emergency and computed tomography (CT) scans. The inclusion criteria included patients treated with TAE for VAPA, including VAPA arising from the coeliac trunk, superior mesenteric artery (SMA), and renal artery. We excluded patients under 18-year-old (1) and cases of empiric TAE (2). A flow chart of the study is detailed in *Figure 1*.

Clinical data

Data on patients consecutively admitted to the interventional room for VAPA were collected. Information regarding patients' demographic data, current medications, comorbidities, clinical presentation, and admission laboratory test results were reviewed. The following data were collected from electronic medical records: patient demographics (i.e., age, gender) and comorbidities prior to the TAE. Current medications included antiplatelet and anticoagulant therapy. Regarding comorbidities, we checked for: high blood pressure, diabetes, current cancer, history of cancer. Hemodynamic instability at admission was defined as a systolic blood pressure (SBP) of <90 mmHg and/or a decrease in systolic pressure despite pharmacological support. Among the admission laboratory results, we reviewed international normalized ratio (INR), thrombopenia, red blood cell (RBC) and plasma transfusion requirements, including number of RBC and plasma units transfused. Imaging data included CT and angiographic findings. CT findings included VAPA location, numbers and size of VAPA, location of bleeding, and presence of active bleeding. Angiographic data included location of embolized vessel, nature of embolic agent, technique of embolization, immediate complications, and duration of procedure. Outcomes included occurrence of complications, rebleeding, type of management for rebleeding, length of hospitalization, and mortality.

Pre-procedure

All patients underwent an abdominal CT (SOMATOM SENSATION, before September 2013 and subsequently, SOMATOM DEFINITION AS 64, Siemens AG, Medical Solution, Erlangen, Germany) for diagnosis of VAPA. Unenhanced and contrast-enhanced liver CT at the arterial and portal phases were performed according to the standard-of-care protocol of our hospital: all patients received ≥90 mL contrast medium (Xenetix 350, Guerbet, Villepinte, France) with a flow rate ≥3 mL/s. A VAPA was defined as hyperattenuating (contrast-enhanced) smooth-walled sac adjacent to an artery, with a communication (16).

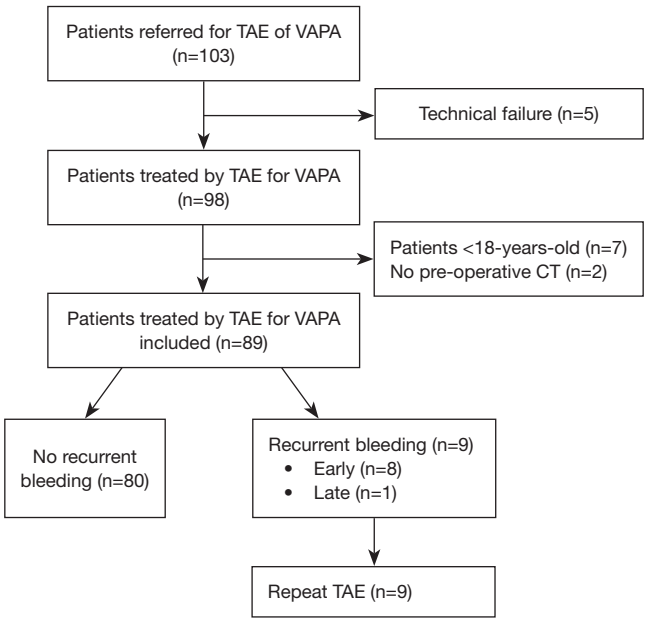

Figure 1 Flow chart of the study population. TAE, transarterial embolization; VAPA, visceral artery pseudoaneurysm; CT, computed tomography.

A bleeding was considered active when iodine contrast was present at the arterial phase and increased at portal phase. The size of the VAPA was determined on the CT scan at the arterial phase, in the long axis, in the axial section.

TAE methods and techniques

Procedures were performed on an angiographic table (Philips Azurion) by one of the hospital's interventional radiologists after a multidisciplinary (surgeon, clinician, radiologist) consultation. Among the 8 radiologists, their years of experience ranged from 2 to 25 years. After local anaesthesia with lidocaine at the puncture site, the right common femoral artery was accessed routinely. Selective catheterism was performed to determine active bleeding using a 4F Cobra catheter or Simmons 5F catheter and a hydrophilic guidewire (Terumo®, Tokyo, Japan). The rate and amount of iodine used for angiography depended on the vessel being catheterized. Supraselective catheterization was performed using a 2.7-F microcatheter (Progreat®, Terumo, Tokyo, Japan) at the discretion of the interventional radiologists. TAE were performed using N-butyl-2-cyanoacrylate (NBCA) (Glubran2®, GEM, Viareggio, Italy), coils (Interlock, Boston Scientific, MA, USA), plug (Amplatzer™ vascular plug) or gelatine sponge (Gelitaspon®, Gelita medical, Amsterdam, The Netherlands). The ratio of NBCA to Lipiodol ranged from 1/1 to 1/3, depended on the distance between the tip of the microcatheter and the target, the type of vessels (presence or absence of anastomosis), the diameter of the target artery, at the discretion of the interventional radiologist. The choice of embolic agents depended on the size of pseudoaneurysm, size of its neck, location of pseudoaneurysm, and collateral supply, all of which were decided at the interventional radiologists' discretion. The embolization technique depended on the intensity of the feeding artery's blood flow, the existence of collaterals, the diameter of the feeding artery, and the size and shape of the pseudoaneurysm sac. In the absence of collaterals and ischemic risk, embolization of the artery upstream of the sac was preferred. In case of risk of recurrence through collateral arteries, a "sandwich" embolization was preferred. If the feeding artery had to be left permeable, embolization by packing the pseudoaneurysm sac was preferred. No spasmolytic agents to reduce bowel peristaltic were administered, and no provocation test was conducted. After TAE, all patients were closely monitored for clinical signs and symptoms suggestive of ischemic complication or recurring bleeding until discharge or death. Clinical findings were supplemented with laboratory tests.

Outcomes

Long-term outcomes, specifically incidence of rebleeding, mortality, and procedure-related complications were collected from patient charts. Abdominal CT follow-up was not a routine practice performed post-TAE in our unit.

Clinical success was defined as the resolution of signs and symptoms of bleeding during the 30-day follow-up period post-TAE without: required endoscopic treatment, surgery, repeat TAE, or death from any cause.

In cases of clinical suspicion of bleeding recurrence or of persistence VAPA persistence, abdominal CTs were performed. This CT was defined as positive if it showed persistent VAPA with or without active bleeding. Recurring events were classified as early events if they occurred ≤30 days post-TAE and as late events if they occurred >30 days following TAE. Complications were defined as per-operative complications if they occurred during the TAE and post-operative complications if they occurred during the 30-day follow-up period. Minor and major complications were recorded using the Society of Interventional Radiology's classification (17). Grades A, B, C were considered minor complications, and grades D, E, F were considered major complications. Overall survival was characterized by the number of days since the procedure relative to the date of last patient contact or death.

Endpoints

We conducted a bivariate analysis focusing on clinically relevant variables. The primary endpoint of the present study was to evaluate predictive factors for clinical success after TAE of VAPA.

Statistical analysis

Results were presented as medians and inter-quartiles for continuous variables and as numbers and frequencies for categorical variables. Predictive factors for clinical success were assessed using uni- and multivariate analyses in a logistic regression model. Odds ratios (ORs) and 95% confidence intervals (CIs) were reported. A statistically significant difference was considered for $P<0.05$. Statistical analyses were performed using R software (version 4.2.2).

Ethical considerations

The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by institutional ethics board of University Hospital of Saint-Etienne (No. IRBN 112021) and informed consent was obtained from all participants.

Results

Within our inclusion criteria, 89 consecutive patients underwent 98 procedures for 107 VAPA in our institute between October 2012 and January 2023. This included 89 procedures and 9 repeat TAE. A flow chart of the patient sample population is presented in *Figure 1*.

Patient characteristics

Detailed patient characteristics are detailed in *Table 1*. The median age was 65 years old (range, 49–74 years), including 68 (76.4%) males. Of the entire sample, 13 (14.6%) patients had a history of cancer, 37 (41.6%) had high blood pressure, 7 (7.9%) had antiplatelet therapy, and 15 (16.9%) patients had anticoagulant therapy. The median hemoglobin was 9 (7.6–11) g/dL and 16 (18.6%) patients had hemodynamic instability at admission. A median of 3 [1–5] RBC units were transfused for 38 (42.7%) patients. A median of 2 [2–4] plasma units were transfused for 19 (21.3%) patients. The main aetiology of VAPA included: blunt trauma [N=26 (29.2%)], acute pancreatitis [N=11 (12.4%)], renal biopsy [N=10 (11.2%)], and partial nephrectomy [N=8 (9.0%)] (*Figure 2*).

Pre-procedure imaging

Pre-operative data are detailed in *Table 2*. All patients underwent pre-operative abdominal CT. The median VAPA size was 10 (2–17.8) mm, and there were 2 (2.2%) associated arteriovenous fistula. Active bleeding was detected in 31 (34.8%) patients, including 9/31 renal, 6/31 duodenal, 5/31 mesenteric, 4/31 hepatic, 3/31 splenic, 2/31 biliary tract, 1/31 gastric, and 1/31 pancreatic pseudocyst active bleedings.

Procedure data

The VAPA endovascular management is detailed in *Table 3*. The main embolized arteries were renal artery n=31 (34.8%), splenic artery n=20 (22.5%) and gastroduodenal artery n=19 (21.3%) (*Figure 3*). Coils alone were used in 58 (65.2%) procedures (*Figure 4*), followed by NBCA and plug in 19 (21.3%) and 8 (9.0%) procedures respectively. The

Table 1 Characteristics of the study population

Variables	Value (n=89)
Age, years	65 [49–74]
Male, n (%)	68 (76.4)
Comorbidities, n (%)	
Diabete	13 (14.6)
Cardiovascular disease	13 (14.6)
High blood pressure	37 (41.6)
Chronic kidney disease	6 (6.7)
History of cancer	13 (14.6)
Clinical presentation, n (%)	
Hemodynamic instability	16 (18.0)
Antiplatelet, n (%)	7 (7.9)
Anticoagulant, n (%)	15 (16.9)
No anticoagulant treatment, n (%)	67 (75.2)
Biology	
INR	1.16 [1–1.36]
Hemoglobin (g/dL)	9 [7.6–11]
Thrombopenia (<150 G/L)	3 (3.4)
Hyperlactatemia (>3 mmol/L)	10 (11.2)
Transfusion, n (%)	38 (42.7)
Number of RBC units per patient	3 [1–5]
Transfusion of plasma, n (%)	19 (21.3)
Number of plasma units per patient	2 [2–4]
Etiology	
Blunt trauma	26 (29.2)
Acute pancreatitis	11 (12.4)
Post operative	
Partial nephrectomy	8 (9.0)
Cephalic duodenopancreatectomy	5 (5.6)
Caudal splenopancreatectomy	1 (1.1)
Cholescystectomy	1 (1.1)
Biliary drainage	6 (6.7)
Renal biopsy	10 (11.2)
Gastroduodenal ulcer	6 (6.7)
Abdominal infection	3 (3.4)
Tumor	
Angiomyolipoma	3 (3.4)
Hepatocellular carcinoma	1 (1.1)
Pancreatic tumor	1 (1.1)
Sarcoma	1 (1.1)
Infection	3 (3.4)
Idiopathic	3 (3.4)

Quantitative parameters are presented as median and interquartile range [25th–75th percentile]. INR, international normalized ratio; RBC, red blood cell.

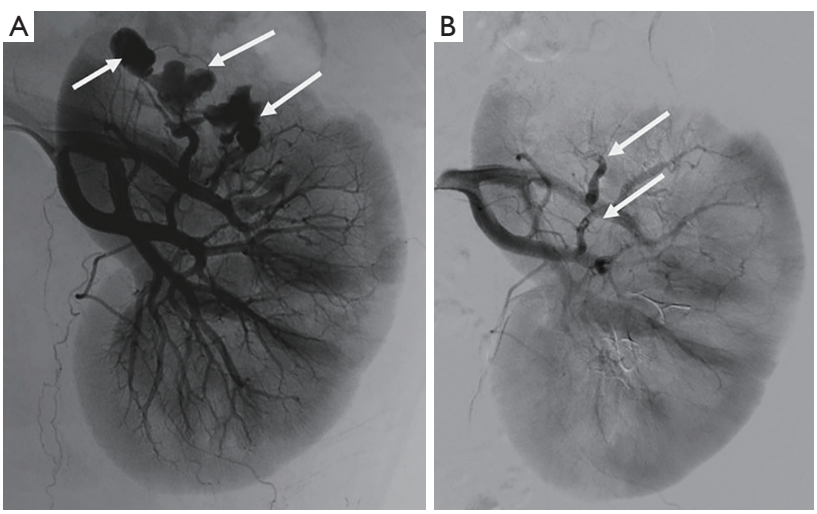

Figure 2 A 54-year-old male patient with 3 asymptomatic pseudoaneurysms from a unique branch of renal artery, following partial nephrectomy. (A) Angiogram showing three pseudoaneurysms (arrows). (B) Control angiogram after TAE using 1.5 mL NBCA/lipiodol mixture (1:3 ratio), showing no filling of the three pseudoaneurysms (arrows). TAE, transarterial embolization; NBCA, N-butyl-2-cyanoacrylate.

Table 2 Pre-operative CT data of the study population

Variables	Value (n=89)
Active bleeding	31 (34.8)
Pseudoaneurysm	89 (100)
Size of VAPA (mm)	10 [2–17.8]
Associated AVF	2 (2.2)
Location of bleeding	
Renal	31 (34.8)
Intraduodenal	14 (15.7)
Peritoneum	14 (15.7)
Spleen	14 (15.7)
Hepatic	7 (7.9)
Biliary tract	4 (4.5)
Pancreatic pseudocyst	3 (3.4)
Intragastric	2 (2.2)
Location of active bleeding	31 (34.8)
Renal	9 (29.0)
Intraduodenal	6 (19.4)
Peritoneum	5 (16.1)
Spleen	3 (9.7)
Hepatic	4 (12.9)
Biliary tract	2 (6.5)
Pancreatic pseudocyst	1 (3.2)
Intragastric	1 (3.2)

Data are presented as n (%) or median and interquartile range [25th–75th percentile]. CT, computed tomography; VAPA, visceral artery pseudoaneurysm; AVF, arteriovenous fistula.

Table 3 Procedural data of the study population

Variables	Value (n=89)
Number of VAPA	107
VAPA per procedure, median number [range]	1 [1–4]
Arteries embolized	
Renal artery	31 (34.8)
Splenic artery	20 (22.5)
Gastroduodenal artery	19 (21.3)
Right hepatic artery	7 (7.9)
Superior mesenteric artery	5 (5.6)
Pancreaticoduodenal artery	3 (3.4)
Dorsopancreatic artery	2 (2.2)
Common hepatic artery	1 (1.1)
Left gastric artery	1 (1.1)
Embolic agents	
Coils	58 (65.2)
NBCA	19 (21.3)
Plug	8 (9.0)
Microparticles	1 (1.1)
NBCA + coils	1 (1.1)
Coils + gelatine sponge	1 (1.1)
Plug + coils	1 (1.1)
Type of TAE technique with coils	58 (65.2)
Inflow artery embolization	35 (60.3)
Sandwich technique	11 (19.0)
Sac packing	11 (19.0)
Inflow artery embolization + sac packing	1 (1.7)
Type of TAE technique with NBCA	19 (21.3)
Inflow artery embolization	14 (73.7)
Inflow artery + sac	2 (10.5)
Inflow + sac + outflow artery	3 (15.8)
Procedure time (min)	60 [45–90]

Data are presented as n (%) or median and interquartile range [25th–75th percentile]. VAPA, visceral artery pseudoaneurysm; NBCA, N-butyl-2-cyanoacrylate; TAE, transarterial embolization.

mean procedure time was 60 [45–90] minutes.

Outcomes

Detailed clinical outcomes after TAE are presented in *Table 4*. During a median follow-up of period of 7.4 (1.3–19.5) months, 12 (13.5%) patients died including 5 (5.6%) patients within the first 30 days. Clinical success was reported for 77 (86.5%) patients. Within the study sample, 9 (10.1%) patients had repeat TAE, including 8 (9.0%) repeat TAE classified as early recurrence (≤30 days). Of these 8 patients, 1 died 2 days after repeat TAE. This patient had been hospitalised for severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection associated with a peptic ulcer and complicated by haemorrhagic shock. For the 7 other mortalities, patients were still alive at least

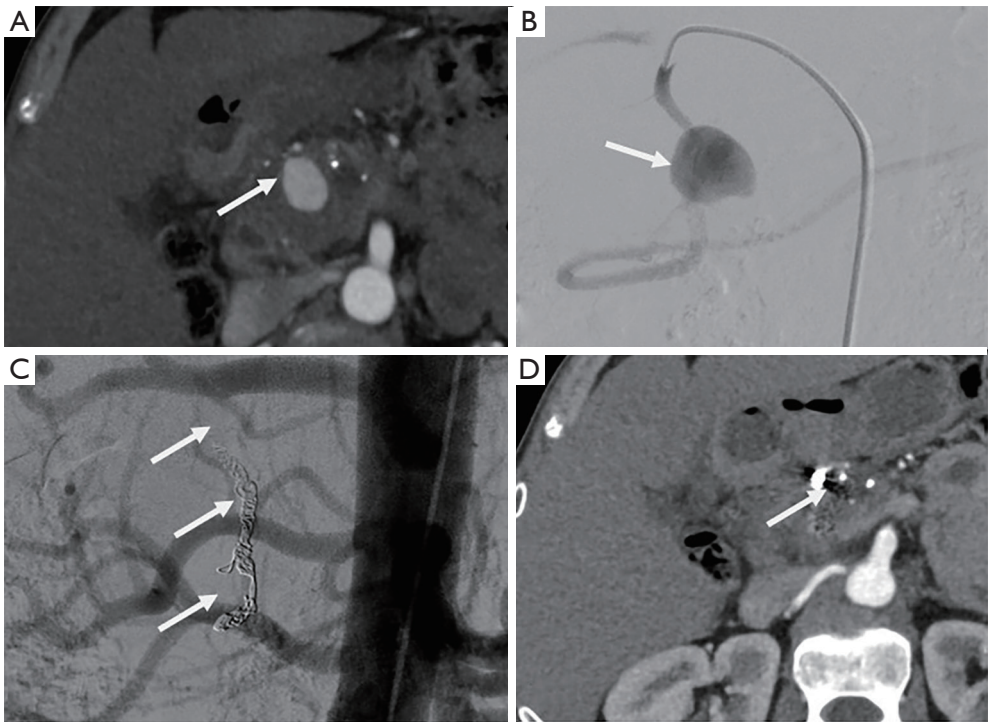

Figure 3 Patient with chronic pancreatitis referred for acute abdominal pain, suggesting acute pancreatitis. (A) Abdominal CT shows a pseudoaneurysm arising from gastroduodenal artery (arrow) without active bleeding. (B) Angiogram in the gastroduodenal artery using a Cobra 4F catheter confirmed VAPA from the gastroduodenal artery, without active bleeding (arrow). (C) Control angiogram after occlusion using front door/back door technique with coils showing no more patency of the pseudoaneurysm (arrows). (D) Control abdominal CT scan showing no more filling of the pseudoaneurysm, which suggests complete thrombosis (arrow). VAPA, visceral artery pseudoaneurysm; CT, computed tomography.

30 days following repeat TAE. Following the Society of Interventional Radiology classifications, there were 11 (12.4%) minor complications, including 6 (6.7%) puncture hematoma, 1 (1.1%) dissection, 3 (3.4%) acute renal failure, and 1 (1.1%) splenic infarct >50% of splenic volume following TAE. Within the same classifications, no major complications were reported.

Predictive factors

Prognostic factors are detailed in *Table 5*. There were no differences in clinical success regarding age, gender, history of cancer, blunt trauma, INR, size of pseudoaneurysm >10 mm, >1 pseudoaneurysm, active bleeding, embolization of gastroduodenal artery, use of NBCA, or use of coils (P>0.05).

In univariate analysis, hemoglobin level [OR =1.497 (1.084–2.251), P=0.027] was associated with clinical success, whereas gastrointestinal bleeding [0.149 (0.039–0.559), P=0.005] and number of RBC transfusions [OR =0.710 (0.545–0.908), P=0.007] were associated with clinical failure. Multivariate analysis for factors associated with overall survival in the entire study cohort showed no statistical independent factors for clinical success.

Discussion

This study provides evidence for a satisfactory safety profile of TAE for VAPA with high clinical success (86.5%). Results show that hemoglobin levels were associated with clinical success and that increased quantities of RBC transfusions and gastrointestinal bleedings were associated with a higher risk of clinical failure. The published literature on VAPA TAE has focused on the embolic agents used to treat VAPA (10), TAE of VAPA in children (11), on particular locations (12), in the context of pancreatitis (13), or has focused on both VAPA and visceral aneurysm (VAA) (7). Omar *et al.* (14) showed 93.5% clinical success, no 30-day mortality and

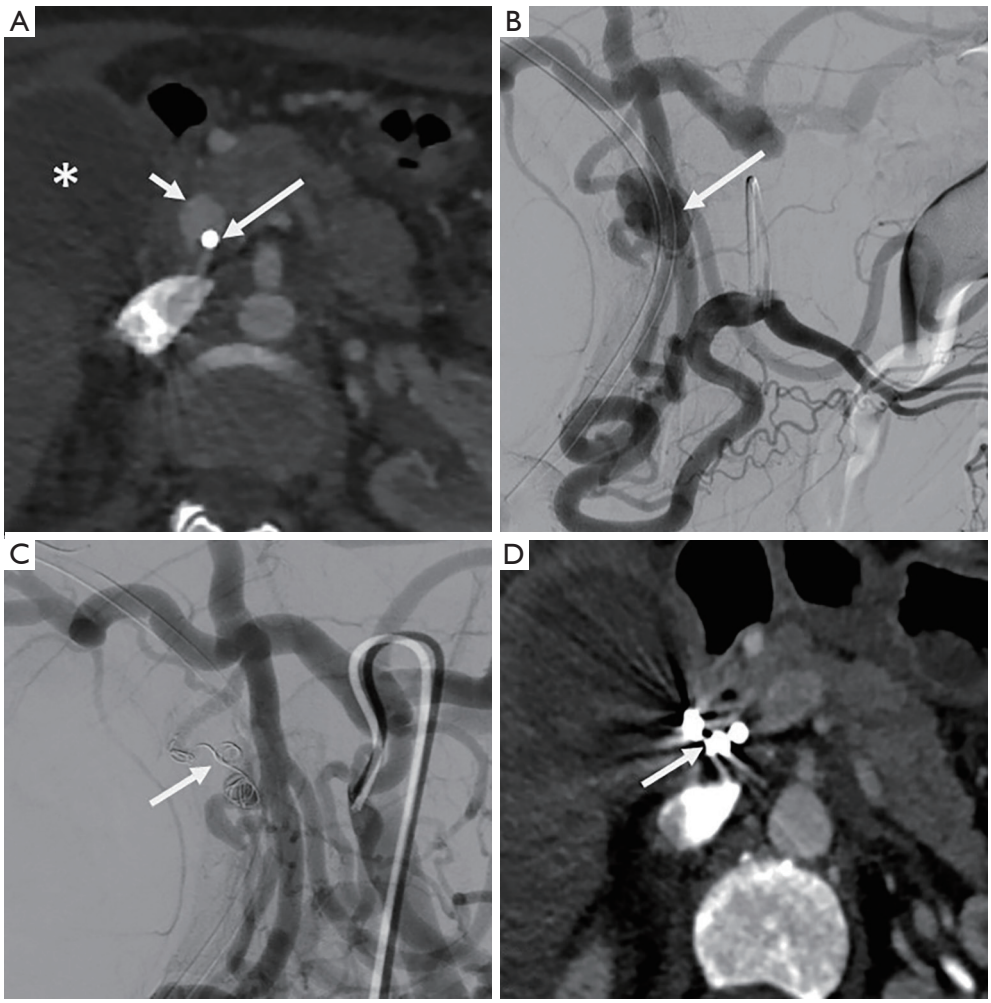

Figure 4 A 35-year-old female referred for haematemesis in a context of metastatic breast cancer. The patient had main bile duct extrinsic compression due to peritoneal carcinosis, with endoscopic placement of plastic stent in the main bile duct. (A) Abdominal CT showing a 12×12 mm VAPA in the main bile duct (short arrow) in contact with the plastic stent (long arrow), without active bleeding, but blood in the gallbladder (star). (B) Angiogram using Side probe in the SMA confirmed VAPA (arrow), with retrograde flow due to median arcuate ligament. (C) The feeding artery was occluded by back door/front door method using 1 fibered coil (arrow). (D) Control CT angiogram showing complete occlusion of the VAPA and artifacts of coils (arrow). CT, computed tomography; VAPA, visceral artery pseudoaneurysm; SMA, superior mesenteric artery.

2.2% repeat TAE among 46 patients treated for VAPA. Shimohira *et al.* (15) showed a high technical success (100%), a low post-embolization mortality (2%), despite 24/47 (51%) minor complications including parenchymal infarcts. To our knowledge, this study is the first to evaluate factors associated with clinical success after TAE of VAPA. The 30-day mortality (5.6%) was relatively low in this study. In contrast, the day-30 mortality of patients treated by TAE for spontaneous soft-tissue hematoma is relatively high (26.8%) (18,19). Our study population consisted of patients with not very severe initial clinical presentations: 16 (18.6%) had hemodynamic instability at diagnosis, 10 (11.2%) had hyperlactatemia, and only 31 (34.8%) had active bleeding on pre-operative CT. In contrast, in a study from Extrat *et al.*, 25/68 (36.8%) patients treated for gastrointestinal bleeding by TAE had hyperlactatemia, 62/68 (91.2%) patients required transfusion, and 15/68 (22.1%) died during the 30-day follow-up period (20). The association of gastrointestinal bleeding and clinical failure may be explained by several factors. First, gastrointestinal bleeding

Table 4 Clinical outcomes of the study population

Variables	Value (n=89)
Clinical success	77 (86.5)
Mortality during follow-up	12 (13.5)
Day-30 mortality	5 (5.6)
Minor complications	11 (12.4)
Puncture hematoma	6 (6.7)
Arterial dissection	1 (1.1)
Acute renal failure	3 (3.4)
Splenic infarct >50%	1 (1.1)
Major complications	0 (0)
Rebleeding	
Early ≤30 days	8 (9.0)
Delayed >30 days	1 (1.1)
Management of early rebleeding	
Repeat TAE	8 (9.0)
Conservative management	0 (0)
Surgery	0 (0)
Median of follow-up (months)	7.4 (1.3–19.5)

Data are presented as n (%) or median and interquartile range (25th–75th percentile). TAE, transarterial embolization.

Table 5 Predictive factors for clinical success following transarterial embolization for VAPA

Characteristics	Univariate analysis		Multivariate analysis	
	OR (95% CI)	P value	OR (95% CI)	P value
Demographics data				
Age <40 years	0.985 (0.949–10.017)	0.672		
Male	1.401 (0.382–4.822)	0.594		
Active cancer	0.402 (0.105–1.703)	0.188		
Gastrointestinal bleeding	0.149 (0.039–0.559)	0.005	0.380 (0.059–2.471)	0.3
Blunt trauma	5.289 (0.947–99.336)	0.12		
Biological data				
INR	0.940 (0.391–3.871)	0.903		
Hemoglobin level	1.497 (1.084–2.251)	0.027	1.153 (0.752–1.864)	0.528
Number of RBC	0.710 (0.545–0.908)	0.007	0.731 (0.523–1.009)	0.053
CT imaging data				
>1 pseudoaneurysm	1.833 (0.306–35.181	0.58		
Size of pseudoaneurysm >10 mm	1.680 (0.493–6.117)	0.409		
Active bleeding	0.323 (0.088–1.13)	0.076		
TAE data				
Gastroduodenal artery	0.339 (0.094–1.279)	0.097		
Use of NBCA	3.356 (0.590–63.424)	0.075		
Use of coils	0.331 (0.048–1.368)	0.172		

In univariate analysis, hemoglobin level, gastrointestinal bleeding and number of RBC transfusions were associated with clinical outcomes (P<0.05). Multivariate analysis showed no statistical independent factors for clinical success. VAPA, visceral artery pseudoaneurysm; OR, odds ratio; CI, confidence interval; INR, international normalized ratio; RBC, red blood cell; CT, computed tomography; TAE, transarterial embolization; NBCA, N-butyl-2-cyanoacrylate.

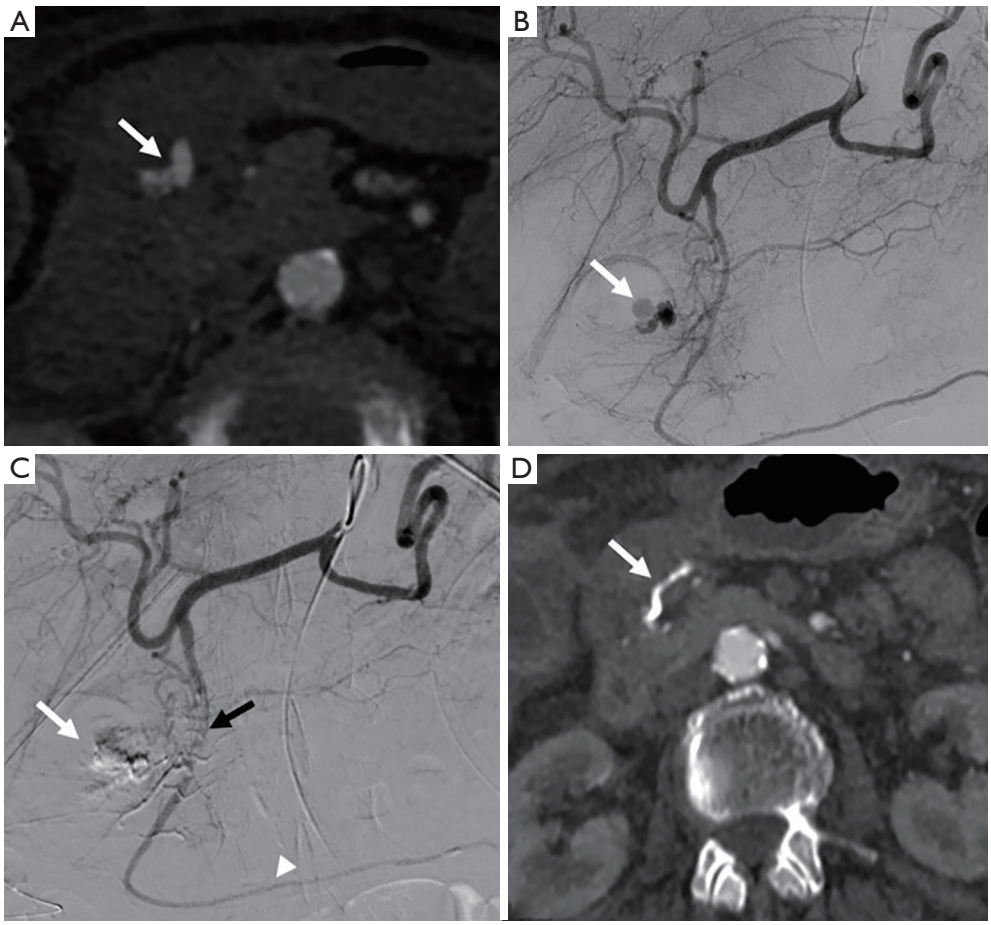

Figure 5 A 78-year-old female patient presenting with hematemesis in a context of perforated gastric ulcer treated by surgical suture. Patient had persistent hematemesis after surgery. (A) Abdominal CT angiogram showing a VAPA in the lumen of the second duodenum, with active bleeding (arrow). (B) Angiogram showing irregular VAPA arising from a branch of gastroduodenal artery (arrow). (C) Control angiogram after TAE with 1 mL NBCA/lipiodol mixture (ratio 1:1) showing no more filling of the pseudoaneurysm (white arrow), patency of gastroduodenal artery (black arrow) and right gastroepiploic artery (arrowhead). (D) Control CT scan at one day post-operation showing no more filling of the VAPA (arrow). CT, computed tomography; VAPA, visceral artery pseudoaneurysm; TAE, transarterial embolization; NBCA, N-butyl-2-cyanoacrylate.

occurred in a rather frail, elderly population, compared to other bleeding sites. Moreover, intraluminal bleeding does not result in a natural compression of adjacent organs such as is the case for bleeding from the liver, spleen, or kidney. In addition, the initial clinical presentation of the older patients appeared to be more critical. Our study shows that a high number of RBC transfusion is a risk factor for clinical failure. This is in line with previous studies that show a link between post-procedure transfusion and technical failure after vascular procedures. Zacà *et al.* reported that the perioperative need for RBC transfusions was strongly related to the occurrence of major adverse cardiac events (OR: 2.67, 95% CI: 1.52–4.68, P=0.001) and 1-year mortality (hazard ratio: 2.14, 95% CI: 1.48–3.09, P=0.0001) (21). Recently, a multicentric study involving trauma patients undergoing resuscitative endovascular balloon occlusion of the aorta reported that RBC transfusion within 4 hours was strongly associated with overall survival (22). In our study sample, 9 (10.1%) patients required repeat TAE, including 8 patients who experienced early recurrence of bleeding. Initial procedures included using coils, mainly with the inflow artery occlusion technique. This is in line with previous literature. Spiliopoulos *et al.* (23) showed 6.1% repeat TAE of the target lesion, whereas Omar *et al.* (14)

showed a need for repeat TAE for only 1/47 (2.1%) patient. It is worth noting that in our sample and among patients treated by repeat TAE, 1 patient died within 30 days, which is in line with previous studies.

The choice of the embolic agent depends on the size of the target artery, the location of the microcatheter in relation to the VAPA, the blood flow in the target artery and the VAPA, the risk of ischaemic complications, the severity of the clinical presentation and the clinician's habits. The most commonly used embolic agent to treat VAPA in our sample was coils [N=58/89 (65.2%)], which aligns with previous literature (24). It has the advantage of being easy to handle, even for operators with less experience. NBCA was used in N=19 (21.3%) procedures. NBCA allows immediate occlusion of the target vessel, even in the case of coagulation disorders, which contrasts with coils (25). Additionally, NBCA allows for the occlusion of target arteries (diameter <1 mm), which coils do not allow for (*Figure 5*). This can be useful, particularly in the case of hemodynamic instability, or in case of the use of vasopressors such as noradrenaline (26). Furthermore, in case of tortuous vessels or failure to catheterize target vessel, NBCA allows for the rapid occlusion of the pseudoaneurysm sac, backdoor and frontdoor. In addition, this allows for a rapid procedure and for the simultaneous occlusion of all VAPA. However, the importance of the choice of embolic agent must be nuanced. Indeed, neither coils nor NBCA were statistically associated with clinical success in our study.

There were few minor complications. The main complication was femoral hematoma, occurring in 6 (6.7%) patients. This risk depends mainly on the location of bleeding. Previous studies have shown that the ischemic risk secondary to occlusion of the gastroduodenal artery and pancreatic duodenal arches is very low, except in cases of coeliac trunk stenosis secondary to median arcuate ligament. Only one splenic infarct following TAE of an extra-parenchymal splenic pseudoaneurysm was reported. Regarding TAE gastrointestinal bleeding, the rate of ischemic complications reported in earlier studies appears to be greatly overestimated (27,28).

The use of covered stents has been shown to be useful in treating patients with pseudoaneurysms. Venturini *et al.* describes a slightly better efficacy of a covered stent compared to coiling in treating VAA and VAPA (29). However, covered stenting was feasible in only 20% of cases in their study. Pedersoli *et al.* (30) showed clinical efficacy of stent graft placement to treat pseudoaneurysm of the hepatic arteries, despite a low mid-term patency (40%), even if most stent thrombosis are asymptomatic. Furthermore, covered stents may expose patients to sepsis (31) and increase migration (32). Sac packing is seen as dangerous to treat VAPA, as it increases the risk of sac rupture during packing. However, in some cases, it may allow filling the VAPA while maintaining patency of the feeding artery (33). In our study, this technique was used in 11/89 (12.4%) cases without sac rupture during or post-procedure. This technique allowed to keep patency of the feeding artery, with only 1 patient needing a repeat TAE due to partial recanalization of the VAPA 1 month after the initial procedure.

Our study has some limitations. This was a retrospective monocentric study, with biases inherent to this type of study. The number of patients included in this study was limited, and the predictive factors found should be analyzed with caution. However, to our knowledge, our study includes a relatively larger number of patients compared to other retrospective studies.

Conclusions

In conclusion, this study shows a satisfactory safety and efficacy profile in patients treated for TAE for VAPA. Hemoglobin levels, number of RBC transfusions and gastrointestinal bleedings seem to be associated with clinical outcomes. Further larger multicentric studies are needed to support these data.

Acknowledgments

The authors thank Michael J. Deml, PhD, MA for proofreading the manuscript.
Funding: None.

Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist (available at https://qims.amegroups.com/article/view/10.21037/qims-24-463/rc).

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://qims.amegroups.com/article/view/10.21037/qims-24-463/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are

appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by institutional ethics board of University Hospital of Saint-Etienne (No. IRBN 112021), and informed consent was obtained from all participants.

References

1. Madhusudhan KS, Venkatesh HA, Gamanagatti S, Garg P, Srivastava DN. Interventional Radiology in the Management of Visceral Artery Pseudoaneurysms: A Review of Techniques and Embolic Materials. Korean J Radiol 2016;17:351-63.
2. Regus S, Lang W. Rupture Risk and Etiology of Visceral Artery Aneurysms and Pseudoaneurysms: A Single-Center Experience. Vasc Endovascular Surg 2016;50:10-5.
3. Kaur M, Bhatia H, Muktesh G, Gupta P. Hepatic artery pseudoaneurysm secondary to a cholangitic abscess and its spontaneous thrombosis. BMJ Case Rep 2021;14:e247304.
4. Inchingolo R, Ljutikov A, Deganello A, Kane P, Karani J. Outcomes and indications for intervention in non-operative management of paediatric liver trauma: a 5 year retrospective study. Clin Radiol 2014;69:157-62.
5. Carriero S, Lanza C, Biondetti P, Renzulli M, Bonelli C, Piacentino F, Fontana F, Venturini M, Carrafiello G, Ierardi AM. Imaging-Guided Percutaneous Puncture and Embolization of Visceral Pseudoaneurysms: Feasibility and Outcomes. J Clin Med 2022;11:2952.
6. Gamanagatti S, Thingujam U, Garg P, Nongthombam S, Dash NR. Endoscopic ultrasound guided thrombin injection of angiographically occult pancreatitis associated visceral artery pseudoaneurysms: Case series. World J Gastrointest Endosc 2015;7:1107-13.
7. Batagini NC, El-Arousy H, Clair DG, Kirksey L. Open versus Endovascular Treatment of Visceral Artery Aneurysms and Pseudoaneurysms. Ann Vasc Surg 2016;35:1-8.
8. Song C, Dong J, Yu G, Zhou J, Xiang F, Pei Y, Lu Q, Jing Z. Comparison of open surgery and endovascular procedures as a therapeutic choice for visceral artery aneurysms. Vascular 2018;26:387-92.
9. Extrat C, Grange S, Chevalier C, Williet N, Phelip JM, Barral FG, Le Roy B, Grange R. Safety and efficacy of emergency transarterial embolization for mesenteric bleeding. CVIR Endovasc 2022;5:5.
10. Madhusudhan KS, Gamanagatti S, Garg P, Shalimar, Dash NR, Pal S, Peush S, Gupta AK. Endovascular Embolization of Visceral Artery Pseudoaneurysms Using Modified Injection Technique with N-Butyl Cyanoacrylate Glue. J Vasc Interv Radiol 2015;26:1718-25.
11. Seetharaman J, Yadav RR, Srivastava A, Sarma MS, Kumar S, Poddar U, Yachha SK. Gastrointestinal bleeding due to pseudoaneurysms in children. Eur J Pediatr 2022;181:235-43.
12. Kochar S, Sharparis Y, Banerjee B, Karasek M, Brennan S. Endovascular Coil Embolization of Superior Mesenteric Artery Branch Pseudoaneurysm. Cureus 2021;13:e18014.
13. Maatman TK, Heimberger MA, Lewellen KA, Roch AM, Colgate CL, House MG, Nakeeb A, Ceppa EP, Schmidt CM, Zyromski NJ. Visceral artery pseudoaneurysm in necrotizing pancreatitis: incidence and outcomes. Can J Surg 2020;63:E272-7.
14. Omar MKM, Othman MHM, Morgan R, Abdallah AH, Seif H, Zidan M, Khairallah M, El-Aleem RA. Analysis of outcomes of endovascular embolisation: A cross-sectional two-center study on 46 visceral artery pseudoaneurysms. CVIR Endovasc 2021;4:60.
15. Shimohira M, Nagai K, Ohta K, Sawada Y, Nakayama K, Shibamoto Y. Safety of Transcatheter Arterial Embolization for Visceral Artery Pseudoaneurysms: Incidence of Intraprocedural Rupture. Vasc Endovascular Surg 2021;55:361-6.
16. Saad NE, Saad WE, Davies MG, Waldman DL, Fultz PJ, Rubens DJ. Pseudoaneurysms and the role of minimally invasive techniques in their management. Radiographics 2005;25 Suppl 1:S173-89.
17. Khalilzadeh O, Baerlocher MO, Shyn PB, Connolly BL, Devane AM, Morris CS, Cohen AM, Midia M, Thornton RH, Gross K, Caplin DM, Aeron G, Misra S, Patel NH, Walker TG, Martinez-Salazar G, Silberzweig JE, Nikolic B. Proposal of a New Adverse Event Classification by the Society of Interventional Radiology Standards of Practice Committee. J Vasc Interv Radiol 2017;28:1432-1437.e3.
18. Ierardi AM, Ascenti V, Carrafiello G. How to Manage Spontaneous Retroperitoneal Haemorrhage. Cardiovasc

Intervent Radiol 2023;46:496-7.
19. Grange R, Grange L, Chevalier C, Mayaud A, Villeneuve L, Boutet C, Grange S. Transarterial Embolization for Spontaneous Soft-Tissue Hematomas: Predictive Factors for Early Death. J Pers Med 2022;13:15.
20. Extrat C, Grange S, Mayaud A, Villeneuve L, Chevalier C, Williet N, Le Roy B, Boutet C, Grange R. Transarterial Embolization for Active Gastrointestinal Bleeding: Predictors of Early Mortality and Early Rebleeding. J Pers Med 2022;12:1856.
21. Zacà S, Di Stefano L, Esposito D, Mozzetta G, Villa F, Pulli R, Pratesi G, Piffaretti G, Angiletta D; Italian Collaborators for EVAR (ICE) group. Cardiac risk after elective endovascular repair for infrarenal abdominal aortic aneurysm: Results from the Italian Collaborators for EVAR multicenter registry. J Vasc Surg 2024;79:260-8.
22. Yu B, Cho J, Kang BH, Kim K, Kim DH, Chang SW, Jung PY, Heo Y, Kang WS. Nomogram for predicting in-hospital mortality in trauma patients undergoing resuscitative endovascular balloon occlusion of the aorta: a retrospective multicenter study. Sci Rep 2024;14:9164.
23. Spiliopoulos S, Sabharwal T, Karnabatidis D, Brountzos E, Katsanos K, Krokidis M, Gkoutzios P, Siablis D, Adam A. Endovascular treatment of visceral aneurysms and pseudoaneurysms: long-term outcomes from a multicenter European study. Cardiovasc Intervent Radiol 2012;35:1315-25.
24. Ikeda O, Nakasone Y, Tamura Y, Yamashita Y. Endovascular management of visceral artery pseudoaneurysms: transcatheter coil embolization using the isolation technique. Cardiovasc Intervent Radiol 2010;33:1128-34.
25. Loffroy R, Guiu B, D'Athis P, Mezzetta L, Gagnaire A, Jouve JL, Ortega-Deballon P, Cheynel N, Cercueil JP, Krausé D. Arterial embolotherapy for endoscopically unmanageable acute gastroduodenal hemorrhage: predictors of early rebleeding. Clin Gastroenterol Hepatol 2009;7:515-23.
26. Huang YS, Chang CC, Liou JM, Jaw FS, Liu KL. Transcatheter arterial embolization with N-butyl cyanoacrylate for nonvariceal upper gastrointestinal bleeding in hemodynamically unstable patients: results and predictors of clinical outcomes. J Vasc Interv Radiol 2014;25:1850-7.
27. Ichiro I, Shushi H, Akihiko I, Yasuhiko I, Yasuyuki Y. Empiric transcatheter arterial embolization for massive bleeding from duodenal ulcers: efficacy and complications. J Vasc Interv Radiol 2011;22:911-6.
28. Nakayama K, Shimohira M, Nagai K, Ohta K, Kawai T, Sawada Y, Shibata S, Shibamoto Y. Duodenal stenosis after transcatheter arterial embolization for rupture of an inferior pancreaticoduodenal aneurysm. Radiol Case Rep 2021;16:2869-72.
29. Venturini M, Marra P, Colombo M, Alparone M, Agostini G, Bertoglio L, Sallemi C, Salvioni M, Gusmini S, Balzano G, Castellano R, Aldrighetti L, Tshomba Y, Falconi M, Melissano G, De Cobelli F, Chiesa R, Del Maschio A. Endovascular Treatment of Visceral Artery Aneurysms and Pseudoaneurysms in 100 Patients: Covered Stenting vs Transcatheter Embolization. J Endovasc Ther 2017;24:709-17.
30. Pedersoli F, Van den Bosch V, Sieben P, Barzakova E, Schulze-Hagen M, Isfort P, Keil S, Wiltberger G, Kuhl CK, Bruners P. Stent Graft Placement by Pseudoaneurysm of the Hepatic Arteries: Efficacy and Patency Rate in Follow-up. Cardiovasc Intervent Radiol 2022;45:21-8.
31. Shukuzawa K, Ohki T, Maeda K, Kanaoka Y. Risk factors and treatment outcomes for stent graft infection after endovascular aortic aneurysm repair. J Vasc Surg 2019;70:181-92.
32. Kim J, Lee BH. Jejunal Migration of the Stent-Graft Used for Common Hepatic Artery Pseudoaneurysm. Taehan Yongsang Uihakhoe Chi 2022;83:189-93.
33. Loffroy R, Rao P, Ota S, De Lin M, Kwak BK, Krause D, Geschwind JF. Packing technique for endovascular coil embolisation of peripheral arterial pseudo-aneurysms with preservation of the parent artery: safety, efficacy and outcomes. Eur J Vasc Endovasc Surg 2010;40:209-15.

Cite this article as: Grange R, Habouzit V, Stacoffe N, Magand N, Williet N, Le Roy B, Boutet C, Grange S. Visceral artery pseudoaneurysm: predictive factors for clinical success after transarterial embolization. Quant Imaging Med Surg 2024;14(9):6436-6448. doi: 10.21037/qims-24-463

