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Angiographic Intervention in Patients With a Suspected Visceral Artery Pseudoaneurysm Complicating Pancreatitis and Pancreatic Surgery

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Objective: To assess the clinical effectiveness of angiography and transcatheter intervention in patients suspected of visceral artery pseudoaneurysm complicating pancreatitis and pancreatic surgery.

Design: Retrospective study.

Setting: University hospital.

Patients: A total of 51 patients who underwent mesenteric angiography for a suspected visceral artery pseudoaneurysm following pancreatitis or pancreatic surgery from 1978 to 2010 were included in this study. There were 39 men and 12 women. The mean age was 66 years (range, 21-89 years) at the time of the angiography. Data on patients' demographics, medical history, angiographic findings, treatment, and outcomes were recorded. Of these 51 patients, 27 had acute pancreatitis, 22 had pancreatic cancer, and 2 experienced pancreatic trauma. Embolization was performed for patients with a pseudoaneurysm. One patient was treated with a stent graft.

Main Outcome Measures: The technical success rate of the intervention, the 24-hour and 30-day rebleeding rates, and the 24-hour and 30-day mortality rates were calculated. A multivariate analysis was performed to determine the factors associated with survival following angiography.

Results: Of the 51 patients studied, 23 had a visceral artery pseudoaneurysm involving the gastroduodenal (7 patients), hepatic (5 patients), splenic (5 patients), and other arteries (7 patients). The technical success rate of the intervention (ie, embolization or exclusion with a Stent graft) was 100%. The 24-hour and 30-day rebleeding rates were 4% and 17%, respectively. The 24-hour and 30-day mortality rates were 0% and 9%, respectively. For the 27 patients who had a negative angiographic finding, the 24-hour and 30-day rebleeding rates were 0% and 11%, respectively, and the 24-hour and 30-day mortality rates were 4% and 21%, respectively. The requirement of a large number of blood products prior to angiography was associated with poor outcome.

Conclusion: Embolization was highly effective in treating a pseudoaneurysm complicating pancreatitis and pancreatic surgery. The hemodynamic status at the time of angiography determines overall survival.

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VASCULAR COMPLICATIONS associated with pancreatitis and pancreatic surgery occur at a variable frequency depending on the severity of pancreatitis, the presence of necrosis or pancreatic fistula, and the type of surgery.[1,2] Common vascular complications include hemorrhage due to vascular erosion, pseudoaneurysm, and venous thrombosis.[3] Although a pseudoaneurysm and venous thrombosis may be asymptomatic, patients often present with abdominal pain, melena, and hypotension due to ongoing bleeding in the gastrointestinal tract, the peritoneal cavity, or the retroperitoneum.[4] Expectant management of active hemorrhage is associated with poor outcomes,[5] and surgery is often the only choice in patients with significant hemodynamic instability.[2] Although surgical intervention may stop the bleeding, postoperative morbidity and mortality rates are high.[6-8] Early reports on endovascular therapy for active hemorrhage in these patients provided variable results.[9-11] Although it is currently the preferred early intervention in hemodynamically stable patients, the long-term outcomes of endovascular therapy are not well described. In addition, the outcomes of patients who have a negative angiographic finding are not known. Herein, we aim to study the outcomes of patients who underwent angiography for a suspected visceral artery

pseudoaneurysm in the setting of acute pancreatitis or pancreatic surgery.

METHODS

Our retrospective study was approved by the institutional review board at our hospital, and the requirement to obtain informed consent was waived. Our study was compliant with the Health Insurance Portability and Accountability Act.

Our hospital's electronic medical records were searched for data on patients who had acute pancreatitis or pancreatic surgery and underwent angiography for bleeding or a suspected pseudoaneurysm. The search extended back 30 years, beginning in January 1978 and ending in May 2010. This search resulted in 51 patients, and these patients constituted our study cohort. Seven patients were treated before 2000. The remaining 44 patients were treated between 2001 and 2010. We collected data on patients' demographics, clinical presentation, and medical history, data on computed tomography (CT) and angiographic findings (if available) and endovascular or surgical therapy for bleeding, and follow-up imaging and clinical data.

PATIENTS

There were 39 male patients and 12 female patients. The mean age was 66 years (range, 21-89 years) at the time of the angiography. Of these 51 patients, 39 (76%) presented with active bleeding, 10 (20%) presented with abdominal pain, and 2 (4%) presented with an asymptomatic CT-detected pseudoaneurysm. Of the 39 patients who presented with bleeding, 37 (95%) had bleeding into the gastrointestinal tract (hematemesis or melena), 2 (5%) had bleeding into the retroperitoneum, and 18 (46%) had recurrent bleeding prior to angiography. Their characteristics are given in **Table 1**.

Of the 51 patients, 30 (59%) underwent CT prior to angiography. Of these 30 patients, 7 (23%) had a pseudoaneurysm identified on CT scan, 6 (20%) had a pseudocyst identified, and 3 (10%) had a collection of hemorrhagic fluid but no pseudoaneurysm identified.

TRIAGE OF PATIENTS

Patients with hemodynamic instability received blood products, including fresh frozen plasma, packed red blood cells, and volume expanders (as deemed necessary). Additional measures (intubation and infusion of vasoconstrictors) were applied at the discretion of the clinician. A decision to proceed with angiography was made by the clinician based on hemodynamic status, blood product requirements, and presence of hemorrhage or a pseudoaneurysm on CT scan.

ANGIOGRAPHY

Angiography and subsequent embolization were performed by trained, board-certified interventional radiologists. These procedures were performed either under conscious sedation (n=46) or general anesthesia (n=5). A standard protocol was followed for all patients. Intravascular access was obtained through a right common femoral artery puncture using the modified Seldinger technique,[12] and a femoral arterial sheath was placed. Celiac, superior mesenteric, and inferior mesenteric arteriograms were performed. When angiography demonstrated a pseudoaneurysm or active extravasation, selective angiography was performed, and the bleeding vessel was embolized with particulate materials (such as polyvinyl alcohol particles or gel foam), coils, N-acetyl cyanoacrylate, or a combination of these. Postembolization angiography of the celiac and superior mesenteric arteries was performed in all patients to confirm occlusion of the embolized segment and absent reperfusion of the pseudoaneurysm through collateral vessels. A Stent graft was used to exclude the aneurysm in 1 patient. Selective angiography of the common hepatic, gastroduodenal, left gastric, and splenic arteries was performed as necessary when initial celiac arteriogram showed no abnormality.

The angiography images were reviewed by 2 authors to achieve consensus. If a pseudoaneurysm was seen, the location, number, and maximum diameter of the aneurysm were recorded. The presence of active extravasation was noted. The technical success of embolization (absence of continued perfusion of the pseudoaneurysm or bleeding site) was assessed by use of a postembolization angiogram. Data on the embolization material used were recorded. Data on procedure-related complications were also recorded.

FOLLOW-UP

All patients were followed up clinically. Patients received blood products as necessary following angiography. If there was rebleeding, a second angiography was performed. Surgical intervention was performed as clinically indicated (such as continued bleeding following embolization).

We recorded the occurrence of rebleeding following angiography and further management. The number of blood transfusions required for stabilization of the patient was recorded for all patients. Any adverse events related to angiography or embolization were recorded. The final outcome of the patient (death, stable, or discharged) were recorded. The follow-up CT scans were reviewed to assess the effect of embolization: any reperfusion of the pseudoaneurysm or asymptomatic complications (such as dissection, liver infarction, or splenic infarction).

DATA ANALYSIS

The rate of technical success of transcatheter embolization was recorded. The clinical success of embolization, defined as cessation of bleeding with no further requirement of blood products, was assessed. The 24-hour and 30-day rebleeding rates and the 24-hour and 30-day mortality rates were calculated. A multivariate analysis was performed to determine the factors associated with survival following angiography. A P value of less than .05 was considered to be statistically significant.

RESULTS

All 51 patients (100%) underwent angiography successfully. Of these 51 patients, 23 (45%) had a pseudoaneurysm or active extravasation determined by angiography, and 28 (55%) had a negative angiographic finding with no evidence of a pseudoaneurysm or active extravasation. The mean (SD) time to angiogram from the onset of symptoms was similar in both groups (9.6 [14.5]days for patients with a positive angiographic finding vs 9.3 [9.6] days for patients with a negative angiographic finding). The mean time to angiography from the last bleeding episode (<24 hours) was similar in both groups.

PATIENTS WITH POSITIVE ANGIOGRAPHIC FINDINGS

There were 17 men and 6 women with a mean age of 65 years (range, 47-84 years) in this group (Table 1). Of these 23 patients, 8 (35%) underwent a Whipple procedure, 9 (39%) underwent pancreatic debridement, 2 (9%) un-

Table 1. Patient Characteristics

Characteristic	All Patients (n=51)	Angiography Finding, No. of Patients	
		Positive (n=23)	Negative (n=28)
Sex			
M	39	17	22
F	12	6	6
Mean age (range), y	66 (21-89)	64 (21-84)	67 (40-89)
Clinical problem			
Acute pancreatitis	27	12	15
Pancreatic or bile duct malignancy	22	9	13
Pancreatic trauma	2	2	0
Clinical presentation			
Bleeding	39	19	20
Abdominal pain	10	2	8
Asymptomatic	2	2	0
Comorbidity			
Hypertension	29	9	20
Diabetes	11	4	7
Alcoholism	14	6	8
Hyperlipidemia	17	5	12
Surgical procedure prior to angiography			
Whipple procedure	21	8	13
Middle pancreatectomy	1	1	0
Pancreatic debridement	20	9	11
Drainage of a pseudocyst	4	2	2
Splenectomy	1	1	0
Cholecystectomy	1	1	0
CT-guided biopsy	1	1	0
Blood or blood product transfusions prior to angiography, No.			
FFP or cryoprecipitate			
Mean (SD)		5 (7.5)	5 (9.6)
Range		0-26	0-35
Packed RBCs			
Mean (SD)		11.8 (11.8)	7.3 (8.1)
Range		0-46	0-26
Blood or blood product transfusions following angiography, No.			
FFP or cryoprecipitate			
Mean (SD)		7.2 (16.9)	4.5 (7.8)
Range		0-76	0-29
Packed RBCs			
Mean (SD)		9.8 (14.9)	8.2 (9.3)
Range		0-48	0-37
Results following angiography, %			
24-h rebleeding rate		4	0
24-h mortality rate		0	4
30-d rebleeding rate		17	11
30-d mortality rate		9	21
Overall mortality due to bleeding		13	7

Abbreviations: CT, computed tomography; FFP, fresh frozen plasma; RBCs, red blood cells.

Table 2. Location of the Pseudoaneurysms in 23 Patients

Artery	Pseudoaneurysms, No. (%)
Gastroduodenal	7 (29)
Splenic	5 (21)
Common hepatic	3 (13)
Inferior pancreaticoduodenal	3 (13)
Left hepatic	2 (8)
Left gastric	2 (8)
Dorsal pancreatic	1 (4)
Epiploic	1 (4)
Total	**24 (100)**

derwent drainage of a pseudocyst, and 1 (4%) underwent middle pancreatectomy (Table 1). One patient had a cholecystectomy, another had a splenectomy, and another had a CT-guided pancreatic biopsy. All patients except for one received transfusion of packed red blood cells (mean, 22 packs; range, 0-91 packs) and/or fresh frozen plasma (mean, 12 packs; range, 0-76 packs).

By use of angiography, it was determined that 23 patients had a total of 24 pseudoaneurysms, with 1 patient having 2 common hepatic artery pseudoaneurysms. Active contrast extravasation was seen in 6 patients (26%) at the time of angiography. The locations of these pseudoaneurysms are listed in **Table 2**. Of 8 patients (35%) who underwent a Whipple procedure, 4 had a pseudoaneurysm that involved the stump of the gastroduodenal artery, 2 had a pseudoaneurysm that involved the common hepatic artery, 1 had a pseudoaneurysm that involved the left hepatic artery, and 1 had a pseudoaneurysm that involved the splenic artery. The sizes of the pseudoaneurysms ranged from 0.4 to 3.1 cm, with a mean diameter of 1.7 cm.

Embolization was performed for all 23 patients, using coils (15 patients [65%]) (**Figure**), a combination of coils and particulate materials (4 patients [17%]), a combination of coils and N-acetyl cyanoacrylate (1 patient [4%]), and particulate materials (2 patients [9%]). In 1 patient (4%), coil embolization of a gastroduodenal artery pseudoaneurysm was not successful owing to an intraprocedural rupture of the aneurysm, and a stent graft was placed to exclude the aneurysm successfully. Thus, the overall success rate of angiographic intervention was 100%.

Following embolization, 1 patient rebled within 24 hours (24-hour rebleeding rate, 4%) and underwent repeat angiography that demonstrated active extravasation at the site of prior embolization. This rebleeding was successfully embolized with *N*-acetyl cyanoacrylate. The overall 30-day rebleeding rate was 17% (4 of 23 patients, including the patient who bled within 24 hours). Angiography was repeated for 2 of the 3 patients. Angiography demonstrated active extravasation into the retroperitoneum in 1 patient, and embolization was successfully performed using particulate materials and coils. This patient was subsequently explored, and a retroperitoneal clot was removed. There was no active bleeding during surgery. In the other patient, angiography failed to reveal any source of bleeding.

No patient died within 24 hours of embolization (24-hour mortality rate, 0%). Two patients died within 30 days of embolization: one patient died of recurrent bleeding and the other died of sepsis (30-day mortality, 9% [2 of 23 patients]). An additional 4 patients died during the same hospital admission. Two patients died of sepsis, and 2 died of

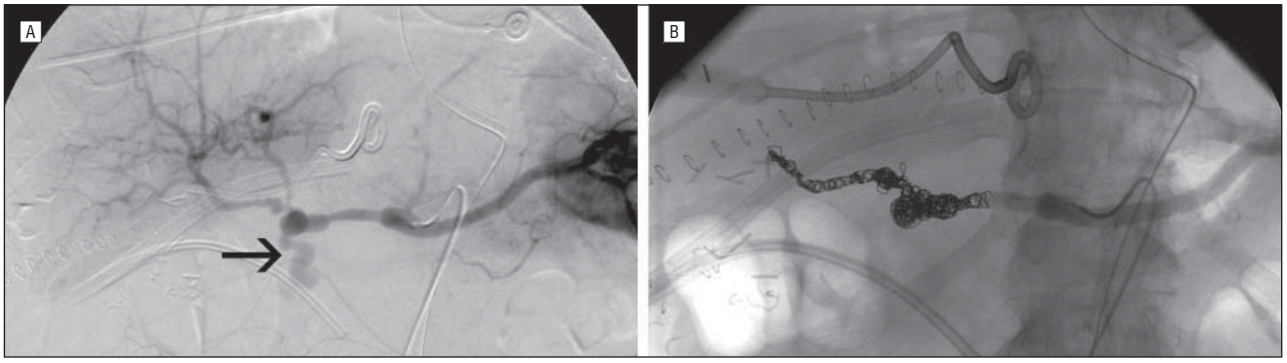

Figure. Celiac angiogram (A) demonstrates a large pseudoaneurysm (arrow) arising at the stump of the gastroduodenal artery in a patient who underwent a Whipple procedure. There is some irregularity of the right hepatic and common hepatic arteries. The aneurysm was successfully embolized with coils (B).

recurrent bleeding. Thus, the overall mortality rate due to bleeding was 13% (3 of 23 patients).

All patients who underwent embolization were followed up clinically over a mean (SD) period of 16 (27) months. There were no instances of rebleeding after discharge from the hospital among the 17 patients who survived the initial illness. A CT scan of the abdomen, available for 11 of the 17 patients, demonstrated no reperfusion of the pseudoaneurysm in any of these patients.

Five of the 23 patients (22%) had complications related to embolization. End-organ injury in the form of liver infarcts was seen in 2 patients, splenic infarcts in 2 patients, and liver and splenic infarcts in 1 patient. The infarcts were managed without surgical intervention. One patient with a liver infarct died of continued bleeding, and another patient with splenic infarct died of sepsis. The other 3 patients had an uneventful recovery with no hepatic dysfunction.

PATIENTS WITH NEGATIVE ANGIOGRAPHIC FINDINGS

There were 22 men and 6 women with a mean age of 67 years (range, 40-89 years) in this group. Of these 28 patients, 13 (46%) underwent a Whipple procedure, 11 (39%) underwent pancreatic debridement, and 2 (7%) underwent drainage of pseudocyst. All patients received transfusion of packed red cells (mean, 15 packs; range, 0-51 packs) and fresh frozen plasma (mean, 9 packs; range, 0-63 packs). Angiography demonstrated patent celiac, superior mesenteric, and inferior mesenteric arteries with no evidence of active bleeding or a pseudoaneurysm. One patient had a spasm in a branch of the right hepatic artery adjacent to an external biliary drainage catheter with no evidence of pseudoaneurysm or extravasation. This vessel was preemptively embolized with coils. Another patient had a spasm at the origin of the right hepatic artery, which was considered as an indirect sign of injury, and the vessel was embolized with gel foam.

Following angiography, 3 patients rebled within 30 days (30-day rebleeding rate, 11% [3 of 28 patients]); however, none of the patients experienced rebleeding within 24 hours after angiography (24-hour rebleeding rate, 0%). Repeat angiography performed for all 3 patients showed no active bleeding and no pseudoaneurysms, and no embolization was performed. In 1 patient, the bleeding continued, and a third angiogram was also negative for active bleeding or a pseudoaneurysm. There were no complications related to diagnostic angiography in these patients.

One patient died within 24 hours because of continued bleeding (24-hour mortality rate, 4%[1 of 28 patients]). Six additional patients died within 30 days after angiography (30-day mortality rate, 21%). Of these 7 patients, 4 died of sepsis, 1 died of renal failure, 2 (including the one who died within 24 hours) died of recurrent bleeding. Thus, the overall mortality rate due to bleeding was 7% (2 of 28 patients).

DETERMINANTS OF SURVIVAL FOLLOWING ANGIOGRAPHY

A multivariate analysis was performed to determine the factors associated with better survival following angiography. The following factors were assessed: age, sex, diagnosis, type of surgical procedures performed, angiography findings, success of embolization, rebleeding rates at 24 hours and 30 days, and requirement of blood transfusions. The requirement of a large number of blood products (>10 packs) prior to angiography was associated with poor outcome ($P=.04$). No other factors were significantly associated with survival. Although a better 30-day survival was seen in patients who had successful embolization (compared with patients who had no embolization procedure), this did not reach statistical significance ($P=.10$).

COMMENT

Hemorrhagic complications following pancreatitis and pancreatic surgery are multifactorial, involving arteries, blood vessels, and capillaries.[3] Arterial complications are often secondary to pseudoaneurysm formation or direct arterial erosion and also secondary to enzymatic degradation of the arterial wall by either the pancreatic enzymes or sepsis, direct erosion by a pseudocyst, or traumatic injury to small arteries during surgery or percutaneous interventions.[3,8,13] Venous bleeding is usually secondary to splenic venous thrombosis and subsequent bleeding from gastric varices.[8,14,15] The factors that influence the incidence of hemorrhagic complications in-

clude the presence of pancreatic fistula, the type of surgery (Whipple vs distal pancreatectomy), the presence of pancreatic necrosis, aggressive debridement in patients with necrotizing pancreatitis, sepsis, and the presence and size of the pseudocyst.[1,2,16-21]

The management of hemorrhage in these patients is often difficult and complex despite advances in surgery and endovascular therapy.[2] The reported mortality rates range from 20% to 50%.[20,22] Although there is a consensus on the approach for management of hemorrhage, the outcomes are not uniform.[20] In general, hemodynamically stable patients are first considered for angiography.[2] Embolization is performed if a pseudoaneurysm or active extravasation is found and if the culprit vessel is accessible and can be safely embolized.[2,17,23] Surgical intervention is considered for unstable patients and when embolization fails or is not feasible.[2,24,25] Given the differences in selection of patients for either procedure, the outcomes of these procedures are not similar,[20] and direct comparison of success and complications is uncertain. However, the complementary roles of percutaneous embolization and surgery appear to be necessary for better outcomes.

The results of our study need to be assessed within its limitations. First, the study patients were selected for angiography because of bleeding during or following acute pancreatitis or pancreatic surgery. Patients who initially underwent emergency surgery were not included, and direct comparison between primary surgical intervention and angiographic embolization cannot be inferred from our study. However, given that we included all patients who underwent diagnostic angiography for a suspected visceral artery pseudoaneurysm, the outcomes of patients with and without an identifiable and treatable lesion after angiography can be compared. Similar to prior reports,[20] our study demonstrated a high technical success in embolizing the pseudoaneurysms. Prior reports[2,16,20,26] indicated 80% to 100% technical success rates in occluding a pseudoaneurysm and a 80% success rate in achieving hemostasis. The rebleeding rates following embolization at 24 hours (4%) and 30 days (17%) in our study compare favorably with prior reports[16,20] in which rebleeding rates have ranged from 0% to 100%, with a mean rate of 26%. Higher rebleeding rates were observed in patients with large pseudoaneurysms related to pancreatic pseudocysts.[27]

The overall mortality rate directly related to bleeding following successful embolization was 13% in our study. In pooled data from 9 studies with a total of 202 patients, the overall mortality rate following successful embolization for hemorrhage in acute pancreatitis ranged from 0% to 44%, with a mean rate of 22%.[16] In comparison, the 24-hour and 30-day rebleeding rates in patients with no angiographically identifiable lesion were 0% and 11%, respectively, in our study. The overall mortality rate related to bleeding in this group was 7%.

A multivariate analysis demonstrated no significant correlation between overall survival and success of embolization. Beattie et al[16] also observed no correlation between survival and success of embolization in their study of 19 patients with hemorrhagic pancreatitis. The only factor that was associated with better survival in our study was the low number of transfusions required prior to angiography, suggesting that hemodynamic stability at presentation was the most significant factor for survival in these patients. This was also observed in previous studies.[28,29] The overall all-cause 30-day mortality was similar (26% vs 21%) whether or not angiography identified a bleeding source. This suggests the importance of other comorbidities such as infected necrosis and anastomotic breakdown, which lead to sepsis and multiorgan failure.[1,26] Angiographic intervention is one element of the overall treatment required for these complex patients.

The distribution of the pseudoaneurysms was similar to those observed in prior studies.[20,26] There was a predominance of gastroduodenal artery pseudoaneurysms in our study. The size of the pseudoaneurysms ranged widely, although aneurysms larger than 3 cm were rare in our study. The smaller size of the pseudoaneurysms in our study may reflect the absence of large pseudocysts in our patient population.[27] Active bleeding during angiography was seen in 30% of patients with a pseudoaneurysm in our study. Similar to other reports,[20] the size of the aneurysm was not a predictive factor of rupture. Various embolic materials, either alone or in combination, have been used in our study. This reflects the evolution of technology during the study period, including the availability of microcatheters and new embolic materials. None of the embolized pseudoaneurysms showed recanalization in our study. The rate of delayed recanalization of embolized pseudoaneurysms is said to range from 0% to 20%.[6,30] Liver and splenic infarcts after embolization occurred in 22% of patients but did not require treatment, as in other reports.[31]

In 1 patient, we used a stent graft to exclude the aneurysm. Stent grafts allow distal organ perfusion while excluding the aneurysm from circulation.[32,33] The long-term safety of stent grafts in the proximity of infection is not known.

The role of CT in triaging the patients for angiography needs further supporting evidence. In our study, a pre-angiography CT, which was available for 30 patients, showed a sensitivity of 23% in detecting a pseudoaneurysm, whereas angiography was positive in 23 of 51 patients (45%). A negative CT finding is not always reassuring because it can be a false-negative finding if the pseudoaneurysm is small.

Although our study is retrospective and includes 3 decades of observations, it is unlikely that a prospective study will be possible, given the rarity of the disease and its acute presentation. Nonetheless, although the techniques of embolization changed over time, the operators adhered to a consistent systematic approach for angiography and embolization during the entire period. We included only patients who underwent angiography and not all patients who had bleeding episodes during or following acute pancreatitis and pancreatic surgery. Within these limitations, we have provided new, longer-term data and assessed the factors associated with better survival.

We conclude that angiography and embolization are effective components of the armamentarium of interventions for the management of patients with a visceral artery pseudoaneurysm complicating pancreatitis and pancreatic surgery.

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