Abstract
Bleeding from a pseudoaneurysm after pancreaticoduodenectomy (PD) is one of the fatal complications of this procedure. Bleeding frequently occurs from the stump of the resected gastroduodenal artery, and first line treatment is transcatheter embolization of the hepatic artery, but with the interruption of blood flow through the hepatic artery, there is a risk of liver failure and liver abscess. In recent years, covered stents, which allow for hemostasis while maintaining hepatic blood flow, have come into use.

In this case, upon identifying sentinel bleeding from a pancreatic fistula after PD, we placed a covered stent in the common hepatic artery, which we believe prevented massive hemorrhage. We think that anticipation of arterial rupture upon detecting the pancreatic fistula, frequent evaluation of the patient and monitoring of the drain, and close communication with the interventionalist performing catheterization were crucial to favorable outcome in this case.

Key words: Covered stent, pancreaticoduodenectomy, sentinel bleeding

Introduction
The risk of surgery-related mortality after pancreaticoduodenectomy (PD) has decreased significantly in recent years. However, the rate of postoperative complications has not decreased. In particular, pseudoaneurysm formation with resultant peritoneal bleeding from a pancreatic fistula is a serious complication, with a high mortality rate (1-3).

In this case of sentinel bleeding from the common hepatic artery due to a post-PD pancreatic fistula, we opted to place a covered stent rather than performing conventional transcatheter arterial embolization (TAE), and we report the utility and challenges of this procedure.

Case Report
The patient was an 80-year-old woman. Past medical history included rheumatoid arthritis, for which she had been taking prednisolone 20 mg/day for 10 years.

We performed PD with D2 lymphadenectomy for distal cholangiocarcinoma. Specifically, we performed subtotal stomach-preserving pancreaticoduodenectomy (SSPPD- II a-1) using the modified Child’s reconstruction procedure. For the pancreaticojejunal anastomosis, we used eight sutures at the pancreatic duct-jejunum anastomosis and the Kakita method for pancreaticojejunosotomy. The pancreatic duct diameter was 3 mm and the pancreas was soft.

We placed one closed suction drain at the choledochojejunal anastomosis and another at the pancreaticojejunal anastomosis, both on the dorsal side. The pancreatic duct tube was then passed through the choledochojejunal anastomosis, and was transhepatically drained externally. On postoperative day (POD) 3, the volume of clear colorless pancreatic juice draining into the pancreatic duct tube increased to 300 mL. In addition, C-reactive protein...
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(CRP) and white blood cell (WBC) count were high at 27.8 mg/dL and 32,400/μL, respectively, indicating an inflammatory response, thus, computed tomography (CT) was performed (Fig. 1). Although no clear abscess formation or anastomotic leakage was detected, mild irregular stenosis was noted in the common hepatic artery (▲).

On POD 5, the fluid from the pancreatojejunal anastomosis dorsal drain became cloudy, and the amylase level of the drainage fluid increased to 18,000 IU/L. The fluid in the choledechojejunal dorsal drain remained serous, with a low amylase level. Inflammatory response improved as evidenced by CRP of 5.5 mg/dL and WBC of 19,300/μL, without fever or abdominal complaints, thus despite the formation of a pancreatic fistula, we felt that the drainage was effective, and decided to continue close observation of the patient. The drainage fluid, although small in quantity, continued to be cloudy, and fluid culture grew methicillin-resistant Staphylococcus aureus. Therefore, we changed the antibiotic to linezolid 1,200 mg/day.

On POD 11, fluid from the choledechojejunal anastomosis dorsal drain, which had been serous, transiently turned into fresh blood, then quickly became serous again; we performed an emergent CT on the same day. Although there was no abscess formation, the previously mild, irregular stenotic image of the common hepatic artery had worsened (▲). We decided that this was the stage prior to vessel rupture consequent to
pancreatic fistula and its infection, and thus performed an emergent angiography on the same day. The angiogram, similarly to the CT, revealed an irregular stenosis without aneurysm (Fig. 3).

Because this patient was at high risk of aneurysm formation and subsequent rupture, we considered hepatic artery coil embolization, but decided to use a covered stent instead to preserve hepatic blood flow. The abdominal aorta was very tortuous, and so we approached the celiac artery from the left brachial artery. Our plan was to ultimately place an expanded polytetrafluoroethylene-covered stent (GraftMaster™), thus, we used a 6-French (Fr) system. We used MACH 1™ as the guiding catheter and used a 4-Fr Judkins catheter to advance toward the celiac artery, however, given the curvature of the aorta, the catheter could not be inserted into the ostium, thus, we switched to a Simmons catheter. The guidewire (Agosal XS 0.8™; 0.014 inch) could not pass through the stenosed vessel, so we also used a microcatheter (Corsair™) to pass the lesion. The distance to the proper hepatic artery was short and the support in advancing the catheter was insufficient, so we switched the guidewire to a support wire (Spindle XS 0.7™ 0.014 inch) and advanced the guiding catheter distally. Without performing pre-inflation, we placed the covered stent (GraftMaster™ 3.5 mm/26 mm-3.5 mm/19 mm) by inflating it to 18 atm. Although the expansion was insufficient compared with the surrounding vessel, our plan was to place the stent without damaging the vessel; thus, we completed the procedure without further re-inflation (Fig. 4). Thereafter, we changed the drains once, and treated conservatively. Peritoneal bleeding did not occur, and the pancreatic fistula subsided. The drains were removed on POD 35.

However, the patient’s oral intake did not improve, and with worsening ability to perform activities of daily living, she required rehabilitation. She was eventually discharged from the hospital on POD 82. Contrast CT performed on POD 184 confirmed a patent stent.

Discussion
PD is a procedure that requires extensive dissection and lymphadenectomy, and the pancreas-intestinal anastomosis site, as well as blood vessels and intestinal tracts exposed though lymphadenectomy, can become sources of postoperative bleeding. In particular, pseudoaneurysm formation and peritoneal bleeding due to a pancreatic fistula are serious complications with high mortality rates.

In recent years, with the improvement in CT imaging resolution, pseudoaneurysms can be imaged accurately. Hemorrhage from hepatic artery pseudoaneurysm occurs in 1-18% of post-PD cases, with a reported mortality rate of 14-70% after bleeding. In terms of location, aneurysm formation often occurs at the gastroduodenal artery stump. Sentinel bleeding has been known to occur prior to massive hemorrhage in many cases. The sentinel bleed occurs 6 hours to 10 days prior to the massive bleed, and Brodsky and Turnbull reported that of five cases of post-pancreatectomy hemorrhage, all five had sentinel bleeding in a peritoneal drain or gastric tube.

In contrast, TAE to embolize the vessel proximal and distal to a common hepatic artery aneurysm is widely used in vascular interventional radiology, and this procedure has a significantly high survival rate compared with surgical hemostasis. This difference could be because in open abdominal surgery, determination of the bleeding source is often difficult due to local inflammatory changes or postoperative adhesions, and the postoperative complication rate is also reported to be high.

Nevertheless, occlusion of the common hepatic artery with TAE could result in liver ischemia or liver failure, which needless to say, places a significant burden on patients who are already doing poorly systemically. The reported incidence of liver ischemia varies, but special attention must be made in surgical cases involving liver resection, portal vein embolization, or those without a replacement for the hepatic artery. In addition, even in typical cases, it is difficult to accurately evaluate whether collateral circulation could achieve sufficient hepatic blood flow in emergency situations. In order to avoid the abovementioned risk of liver ischemia, hemostasis methods using stent-assisted coiling (SAC) or covered stents have been reported. SAC is a method which uses an uncovered stent to maintain blood flow in the main artery, after which aneurysmal coiling is performed. This method balances hemostasis and maintenance of circulation, however, disadvantages include difficulty
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in diagnosis and technique, as well as the prolonged time to achieve hemostasis\textsuperscript{15}. In the covered stent method, a stent graft for coronary arteries is placed, and the procedure is easy and can be done quickly. According to a report by Huo et al. of 18 cases, 4 of the 10 cases in which TAE was performed experienced rebleeding, whereas none of the 8 cases in which a covered stent was placed experienced rebleeding\textsuperscript{20}. Still, the covered stent method is the intended use of the stent as a temporary bridge until bypass surgery for a damaged coronary artery rather than for use in an intraperitoneal artery. Therefore, its disadvantages include lack of coverage by insurance in Japan, lack of evidence of long-term patency, and as yet unknown need for anti-platelet therapy\textsuperscript{21}. Furthermore, compared with coiling or SAC, a covered stent requires a device with a larger diameter, and thus may be difficult to place into a spastic vessel. It may also be difficult to place if the hepatic artery has a tortuous course.

The highest priority when bleeding occurs is to stop it as fast as possible. Hepatic arterial blood flow is preserved if possible, but prolonged blood loss should be avoided as that could ultimately be fatal. TAE seems to be the first choice if stent placement is difficult or in cases of massive profuse bleeding. However, when the amount of bleeding is not large or when it is assumed that the bleeding duration is not a contraindication to TAE, covered stents may be considered. It is possible to select SAC with a stent that has better followability than a covered stent. Depending on the shape of the blood vessel and the site of the aneurysm, this may be easier to place than a covered stent\textsuperscript{16}.

In this case, we performed CT imaging at the time of the sentinel bleed and found that the irregular stenosis in the hepatic artery had worsened, and thus quickly performed angiography. We think that the irregular stenosis of the hepatic artery was a finding that suggests vessel wall damage or spam due to pancreatic juice or infection. Whether this vessel would develop an aneurysm and rupture could only be determined by observing the clinical course; thus, coiling and shutting down all hepatic artery blood flow at this stage might be overtreatment. In particular, this case did not have a replacement artery such as a left accessory hepatic artery arising from the left gastric artery, or a right hepatic artery arising from the superior mesenteric artery. Furthermore, the patient was at POD 11 and had poor collateral circulation. Thus, embolization of the common hepatic artery would have resulted in interrupting circulation of all hepatic arteries.

The presence of sentinel bleeding in the majority of cases with major bleeding (89–100\%) is reported in multiple studies\textsuperscript{2,6,22}. However, no study has reported on what percentage of sentinel bleeding would lead to major bleeding.

There is thus no clear basis as to whether treatment is appropriate at the initial stage of just identifying sentinel bleeding and whether follow-up observation is appropriate.

In this case, we clinically judged that there is a high possibility of major bleeding from (1) pancreatic fistula and infection, (2) identification of sentinel bleeding, (3) confirmation of irregular vascular lumen narrowing, and obvious damage to blood vessels.

If stent placement is difficult, either follow-up observation or total hepatic artery embolization using TAE is an option. There is a high possibility of mortality if major bleeding occurs during follow-up observation. However, in cases where major bleeding is unlikely, then TAE may actually be overtreatment.

From the standpoint of prevention of aneurysm formation and massive hemorrhage and maintenance of hepatic circulation, the use of a covered stent was the optimal choice. Cases in which contrast leakage is seen from a pseudoaneurysm in angiography have been reported to have worse outcomes compared with those without contrast leakage, thus, prevention of massive hemorrhage is of utmost importance.

Because there is no standard for the use of anti-platelet agents after GraftMaster\textsuperscript{TM} placement, it was administered at the time of stent placement in percutaneous coronary intervention\textsuperscript{23} and an anti-platelet agent (Biaspirin enteric coated tablet 100 mg) was used. The disadvantage, as with general antiplatelet agents, is the risk of easy bleeding and development of peptic ulcer. This patient needs oral administration of steroids, and we use PPI oral medicine in combination for preventing ulcers.

Conflict of interest: None.
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