Utility of CT in the Diagnosis of Pancreatic Fistula After Pancreaticoduodenectomy in Patients with Soft Pancreas

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OBJECTIVE. The purpose of this study was to evaluate the sensitivity and specificity of routine performance of CT on postoperative day 7 in patients at high risk of pancreatic fistula after pancreaticoduodenectomy.

MATERIALS AND METHODS. Two radiologists analyzed images from CT examinations of 50 patients with soft pancreas 7 days after pancreaticoduodenectomy. Pancreatic fistula was defined at CT as a fluid collection close to the pancreaticogastric or pancreaticojejunal anastomosis. Clinicobiologic criteria for the diagnosis of pancreatic fistula were drain output of any measurable volume of fluid on or after postoperative day 3 that had an amylase content more than three times the serum amylase activity. The final diagnosis of pancreatic fistula was rendered on the basis of clinicobiologic data at hospital discharge or at first readmission.

RESULTS. At hospital discharge or at first readmission, 27 of 50 patients (54%) had a pancreatic fistula. On postoperative day 7, 30 patients (60%) had a total of 51 fluid collections, and CT showed a fluid collection close to the pancreaticogastric or pancreaticojejunal anastomosis in 21 of 51 cases. CT had a sensitivity of 63% (17/27 patients) and a specificity of 83% (19/23 patients) for the diagnosis of pancreatic fistula with four false-positive and 10 false-negative findings. The diagnosis of pancreatic fistula on the basis of clinicobiologic criteria on postoperative day 7 was made in 22 of 27 patients (81%), whereas five cases were false-negative. Four of these patients had CT evidence of pancreatic fistula.

CONCLUSION. In patients at high risk who have undergone pancreaticoduodenectomy, systematic postoperative CT may be proposed as a complementary tool in the diagnosis of pancreatic fistula, particularly for detection of clinically occult pancreatic fistula.

Keywords: CT, pancreas, pancreaticoduodenectomy, pancreatic fistula, soft pancreas

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Pancreaticoduodenectomy is safe in the management of various malignant and benign diseases of the pancreatic head and periampullary region. Although the mortality rate has decreased to approximately 1–2% at high-volume centers, the morbidity rate ranges from 30% to 50% [1–4]. The two most frequent complications of pancreaticoduodenectomy are delayed gastric emptying and pancreatic fistula.

Pancreatic fistula after pancreaticoduodenectomy is a serious complication resulting in prolonged hospital stay, increased costs, readmission, and a mortality rate of 3–9% [5, 6]. Efforts to reduce the incidence of pancreatic fistula have included definition of risk factors [1, 7], improvement of surgical technique [8, 9], and perioperative administration of somatostatin and its analogues [1, 10]. The International Study Group on Pancreatic Fistula has defined pancreatic fistula as "drain output of any measurable volume of fluid on or after postoperative day 3 with an amylase content greater than three times the serum amylase activity" [11].

The overall rate of pancreatic fistula after pancreaticoduodenectomy ranges from 17% in patients in whom the pancreatic remnant has a hard consistency [12] and exocrine pancreatic function and pancreatic juice output are impaired [13] to 25% in cases in which the pancreas is soft [1], that is, the parenchyma is normal [13]. Soft pancreatic texture [1, 3, 13] and small pancreatic duct size [3] are the most important preoperative risk factors for the development of pancreatic fistula.

The diagnosis of pancreatic fistula usually is made an average of 7 days after pancreaticoduodenectomy [5, 14, 15]. Pancreatic fistula diagnosed with repeated assays of pancreatic enzymes in peripancreatic fluid drainage [11, 14, 16] is recognized in only 70–75% of cases [2, 5, 17]. The peripancreatic drains routinely

inserted at the end of pancreaticoduodenectomy by almost all surgeons [18] do not prevent development of complications related to pancreatic fistula, such as the collections and abscesses found in 10–40% of patients [8, 19–21]. Moreover, 5–9% of patients need readmission for fistula or abscess because pancreatic fistula was not diagnosed in the immediately postoperative period [18, 20, 22]. Decreasing the rate of occult or delayed pancreatic fistula should be a reasonable goal.

The proper role of CT in the diagnosis of pancreatic fistula after pancreaticoduodenectomy remains controversial. Although some authors [2, 3] routinely perform postoperative CT and include CT in the criteria for pancreatic fistula diagnosis, others [17] do not recommend CT in the diagnosis of pancreatic fistula because of the high prevalence of transient intraabdominal fluid collections after pancreaticoduodenectomy [22]. In an effort to clarify the role of CT in the diagnosis of pancreatic fistula after pancreaticoduodenectomy, we evaluated the sensitivity and specificity of routine CT on postoperative day 7 in patients at high risk of pancreatic fistula.

Materials and Methods

Institutional review board approval was obtained for review of the patients' medical records. Before undergoing CT, all patients provided written informed consent to allow use of their CT data for research purposes.

Inclusion Criteria

Patients were included in the study if they had undergone pancreaticoduodenectomy for benign or malignant disease of the pancreatic head and distal biliary tract during the 4-year study period, had a soft pancreas, and had undergone abdominal CT on postoperative day 7. Soft pancreas was defined histologically as the absence of fibrosis or the presence of slight fibrosis of the pancreatic stump, that is, grade 0 on the 0–3 scale of the Klöppel and Maillet classification [23].

During the study period, 144 pancreaticoduodenectomies were performed at our hospital. In 62 of the patients, the pancreas had a soft consistency as assessed intraoperatively by the surgeon. All of these patients underwent CT on postoperative day 7, as is routine at our institution for all patients with soft pancreas because of the higher risk of development of postoperative fistula than among patients with a fibrotic pancreas. When perianastomotic collections were detected on postoperative day 7, follow-up CT was performed weekly until resolution occurred. Seven patients were excluded from the study because fibrosis on the transection margin of the pancreas (Klöppel and Maillet grade 1–3) was detected at histologic examination. Five patients were excluded because CT images could not be located. Therefore, the final study group consisted of 50 patients (23 men, 27 women; mean age, 58 years; range, 18–82 years).

Surgical Technique

All patients underwent standard pancreaticoduodenectomy. Reconstruction was by end-to-side pancreaticogastrostomy in 48 of 50 cases (96%) and by end-to-end pancreaticojejunostomy in two cases (4%). Multichannel open passive silicone drains were placed close to the biliary and pancreaticogastric or pancreaticojejunal anastomoses and pulled out through the right or left flank. Surgical drainage output was collected daily, and biochemical amylase level and results of bacteriologic analysis were recorded on days 1, 3, 5, 7, and 10. Serum amylase level was measured on postoperative days 1, 3, 5, 7, and 10. All patients had a nasogastric tube for gastric decompression until return of bowel activity and received octreotide during the 7 postoperative days for prophylaxis of pancreatic fistula [10]. In the absence of clinical or biochemical evidence of pancreatic fistula, oral feeding was allowed on postoperative day 7, and the surgical drain was progressively removed.

Histologic Analysis

Histologic analysis of resected specimens showed 14 cases of pancreatic adenocarcinoma (28%); 10 of intraductal papillary mucinous neoplasm (20%), one of which had malignant transformation; eight of ampullary adenocarcinoma (16%); six of distal common bile duct carcinoma (12%); and five cases of endocrine tumor (10%). Less common findings were three cases of solid pseudopapillary tumor (6%), one case of pseudotumoral cholangitis (2%), one of mass-forming pancreatic tuberculosis (2%), one of duodenal stromal tumor (2%), and one case of duodenal adenocarcinoma (2%).

Definition of Pancreatic Fistula

Pancreatic fistula was defined as the presence of at least one of the two following criteria: first, drain output of any measurable volume of fluid on or after postoperative day 3 that had an amylase content greater than three times the serum amylase activity [11] and, second, anastomotic leakage confirmed at reoperation or percutaneous drainage for major complications, such as abdominal bleeding and sepsis, during the hospital stay or first readmission [1, 8, 20, 22]. First readmission was defined as the first hospitalization for a complication of the initial pancreaticoduodenectomy within 3 months after hospital discharge [24]. The final diagnosis of pancreatic fistula was defined on the basis of the clinical and biochemical data during the hospital stay or at first readmission.

Imaging Protocol

Before and after IV contrast administration, CT was performed with an MDCT scanner (LightSpeed Ultra, GE Healthcare) with a 0.5-second tube rotation time and acquisition of eight slices per rotation. No oral contrast material was administered. Unenhanced CT was performed at 5-mm section thickness and 5-mm intervals, 35-cm field of view, high-speed mode, 15.0 mm/rotation, 120 kVp, and 200 mA. Nonionic iodinated contrast material (2 mL/kg iobitridol, Xenetix 350, Guerbet) was administered with a power injector (MCT, Medrad) through an 18- to 20-gauge angiographic catheter in an antecubital vein at a flow rate of 4–5 mL/s. Acquisition was begun 70 seconds after the start of contrast injection at 5-mm section thickness and 5-mm intervals, field of view to fit, high-quality mode, 7.5 mm/rotation, 120 kVp, and 200 mA. Images were obtained in the craniocaudal direction in all phases. Patients with abnormal biochemical or imaging findings underwent weekly (day 14, day 21, and so on) follow-up CT.

Image Analysis

Two experienced abdominal radiologists (17 and 5 years of experience) in consensus retrospectively analyzed the hard-copy CT images. Both radiologists knew the indication for surgery and type of resection, but they were not aware of the clinical and biochemical findings on postoperative day 7 or the final diagnosis of pancreatic fistula. For each patient, the two radiologists determined the presence (number and location) and imaging features (shape, size, attenuation, homogeneity, wall enhancement) of intraabdominal and retroperitoneal fluid collections on postoperative day 7. Fluid collections were classified into peripancreatic collections (close, that is, immediately adjacent, to the pancreaticogastric or pancreaticojejunal anastomosis) and other collections, according to site (superior recess of lesser sac, subhepatic space, right and left paracolic gutters, root of mesentery) [25]. The presence of air bubbles was recorded for each fluid collection. The radiologists considered any fluid collection adjacent to the pancreaticogastric or pancreaticojejunal anastomosis a pancreatic fistula [26].

The following postoperative changes and complications also were analyzed: findings of acute pancreatitis of the pancreatic remnant (pancreatic necrosis, infiltration of adipose peripancreatic tissue or thickening of the right and left pararenal fascia); normal caliber (< 3 mm) or dilatation of the pancreatic duct; infiltration of the adipose perivascular tissue surrounding the celiac trunk,

superior mesenteric vessels, and hepatic vessels (perivascular cuffing); abnormal abdominal and retroperitoneal lymph nodes, indicated by a short axis longer than 1 cm; vascular involvement, such as main or intrahepatic portal venous thrombosis, hepatic or mesenteric venous thrombosis, and formation of pseudoaneurysms; hepatic or biliary abnormalities or pneumobilia; ascites, pneumoperitoneum, and periportal lymphedema; and extraabdominal complications, such as pleural effusion and atelectasia.

To correlate the results of the image analysis with the final diagnosis of pancreatic fistula at hospital discharge or at first readmission, the two radiologists retrospectively reviewed the clinicobiologic findings in all cases in which a false-positive or a false-negative diagnosis of pancreatic fistula had been made to determine the cause of the incorrect CT diagnosis.

Statistical Analysis

Data are presented as mean ± SD. Categoric variables were compared by use of the Fisher's exact test. A value of $p < 0.05$ was considered to indicate a statistically significant difference. Sensitivity and specificity for the diagnosis of pancreatic fistula with clinicobiologic data and CT findings were calculated.

Results

Pancreatic Fistula and CT Findings

At hospital discharge, 27 of the 50 patients (54%) had a definitive diagnosis of pancreatic fistula. For 25 patients, the diagnosis was based on clinical and biologic data; for one, it was made at reoperation for abdominal bleeding; and for one patient, the diagnosis was based on the elevated level of amylase in aspirate percutaneously obtained from a perianastomotic collection. No patient needed readmission for pancreatic fistula or major complications after hospital discharge.

At CT 7 days after pancreaticoduodenectomy, 20 patients had no intraabdominal fluid collections, but 30 patients (60%) had a total of 51 fluid collections. Sixteen of the 50 patients (32%) had one collection (Figs. 1 and 2), seven (14%) had two collections (Fig. 3), and seven (14%) had three or more collections. Fluid collections were close to the pancreaticogastric or pancreaticojejunal anastomosis (Figs. 1–3) in 21 of 51 cases (41%). These perianastomotic collections were round in six of 21 cases (29%), oval in nine of 21 cases (43%), and of various morphologic configurations in six of 21 cases (29%). The mean long axis of these perianastomotic collections was 4.1 ± 4.9 cm, and the mean short axis was 1.6 ± 0.7 cm. All these collections had fluid attenuation and homogeneous content. At CT, increased attenuation, as typically observed in hematomas, was never seen within the collections. Wall enhancement was seen in four of 21 perianastomotic collections (19%). Air bubbles were seen in six of 51 collections (12%), five of which were perianastomotic (five of 21, 24%).

The presence of a fluid collection close to the pancreaticogastric or pancreaticojejunal anastomosis was considered diagnostic of pancreatic fistula, and CT performed on postoperative day 7 depicted a pancreatic fistula in 21 patients (Figs. 1 and 2). CT had a sensitivity of 63% (17 of 27 patients) and a specificity of 83% (19 of 23 patients). Therefore, there were four false-positive diagnoses (Fig. 4) and 10 false-negative diagnoses (Fig. 5).

False-positive perianastomotic collections were small, having a mean diameter of 3.8 ± 0.7 × 1.8 ± 0.6 cm. Two of four false-positive perianastomotic collections (50%) had a long axis measuring 2 cm or less, but only four of 17 true-positive perianastomotic collections (24%) had a long axis measuring 2 cm or less. These results were not statistically significant ($p > 0.05$). No false-positive collections contained air bubbles. In the 10 false-negative cases at CT, retrospective analysis of the CT images showed that the drainage tube always had been placed immediately adjacent to the pancreaticogastric or pancreaticojejunal anastomosis.

On postoperative day 14, true-positive perianastomotic collections were found in 14 of 17 patients (82%). Fluid collections had enlarged in four patients and were the same size as at the previous examination in 10 patients.

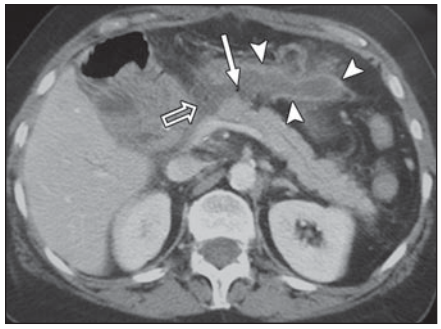

Fig. 1—62-year-old woman 7 days after pancreaticoduodenectomy for duodenal stromal tumor. Transverse contrast-enhanced helical CT scan of abdomen shows perianastomotic fluid collection measuring maximum of 10 × 1 cm close to anastomosis (*open arrow*), containing air bubbles (*arrow*), and exhibiting wall enhancement (*arrowheads*). Pancreatic remnant has normal enhancement without signs of postoperative pancreatitis or dilatation of pancreatic duct. Clinicobiologic diagnosis was pancreatic fistula on postoperative day 7. Both radiologists made correct diagnosis.

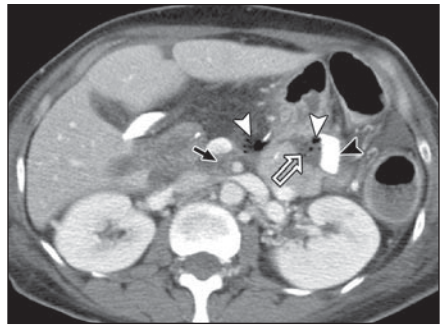

Fig. 2—54-year-old woman 7 days after pancreaticoduodenectomy for pancreatic adenocarcinoma. Transverse contrast-enhanced helical CT scan of abdomen shows perianastomotic fluid collection close to anastomosis (*open arrow*) and containing air bubbles (*white arrowheads*). Drain (*black arrowhead*) is next to anastomosis. Black arrow indicates perivascular cuffing surrounding superior mesenteric vessels. Patient had clinicobiologic diagnosis of pancreatic fistula on postoperative day 7. Both radiologists made correct diagnosis.

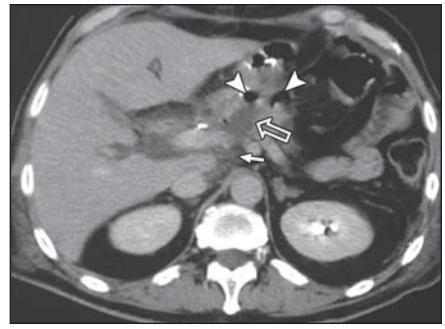

Fig. 3—62-year-old man 7 days after pancreaticoduodenectomy for pancreatic adenocarcinoma. Transverse contrast-enhanced helical CT scan of abdomen shows perianastomotic fluid collection (*open arrow*) close to anastomosis and containing small air bubbles (*arrowheads*). Solid arrow indicates another collection in posterior compartment of superior recess of lesser sac. Drainage tube (not shown) was displaced far from anastomosis in abdominal cavity. On postoperative day 7 patient had no clinicobiologic findings of pancreatic fistula, but both radiologists made correct diagnosis of pancreatic fistula (occult pancreatic fistula). During hospital stay, amylase level became elevated; therefore, patient had diagnosis of pancreatic fistula at hospital discharge.

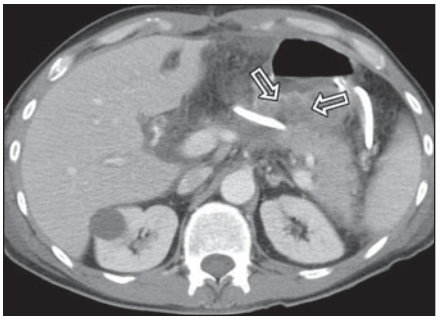

Fig. 4—52-year-old man 7 days after pancreaticoduodenectomy for pseudotumoral cholangitis. Transverse contrast-enhanced helical CT scan of abdomen shows small fluid collection (*arrows*) without air bubbles very close to anastomosis. Both radiologists correctly identified small perianastomotic fluid collection and suspected presence of pancreatic fistula, but clinical and biologic findings were negative for pancreatic fistula on postoperative day 7 and at follow-up until hospital discharge. Collection was not present on CT scan obtained on postoperative day 14.

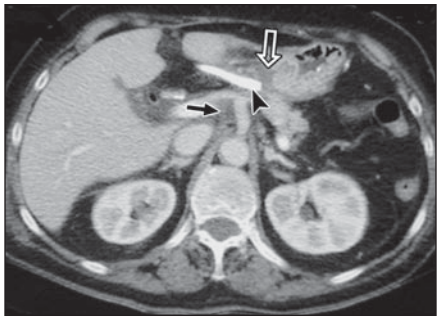

Fig. 5—82-year-old woman 7 days after pancreaticoduodenectomy for duodenal adenocarcinoma. Transverse contrast-enhanced helical CT scan of abdomen shows no perianastomotic fluid collection at anastomosis (*white arrow*). Drainage tube (*arrowhead*) is next to anastomosis. Black arrow indicates perivascular cuffing around celiac trunk. Patient had clinicobiologic diagnosis of pancreatic fistula on postoperative day 7. Both radiologists correctly identified lack of perianastomotic fluid collection. Drain output established diagnosis of pancreatic fistula.

Three of 17 patients (18%) no longer had collections on postoperative day 14. All false-positive perianastomotic collections had disappeared at follow-up: three of four (75%) by postoperative day 14 and one of four (25%) by postoperative day 21.

On postoperative day 7, pancreatic fistulas in 22 of the 50 patients (44%) were diagnosed on the basis of clinicobiologic data alone. The clinicobiologic criteria for the diagnosis of pancreatic fistula on postoperative day 7 had a sensitivity of 81% (22 of 27 patients). In this subgroup of patients, a perianastomotic fluid collection was seen at CT in 13 of 22 patients (59%). Five patients without criteria for diagnosis of pancreatic fistula at postoperative day 7 were diagnosed as having a pancreatic fistula during their hospital stay. CT depicted a perianastomotic fluid collection in four of the five patients (80%).

Other CT Findings on Postoperative Day 7

The 30 nonperianastomotic fluid collections were found in the anterior compartment of the superior recess of the lesser sac in 11 of 51 cases (22%), in the posterior compartment of the superior recess of the lesser sac in six of 51 cases (12%), and in other locations in 13 of 51 cases (25%). No collection was found close to the hepaticojejunostomy or gastrojejunostomy.

All patients had a normal pancreatic remnant with homogeneous parenchymal enhancement and no infiltration of adipose peripancreatic tissue. We detected thickening of the left pararenal fascia in seven cases (14%) and thickening of the right pararenal fascia in one case (2%). None of these patients had clinical or biologic findings of acute pancreatitis.

The pancreatic duct was of normal caliber (< 3 mm) in most patients (47 of 50, 94%). Minimal dilatation (< 5 mm) was found in three of 50 patients (6%). Mesenteric or hepatic perivascular cuffing was present in 14 of 50 patients (28%). Retroperitoneal or celiacomesenteric lymph nodes larger than 1 cm in the short axis were found in three of 50 patients (6%). No abdominal bleeding or pseudoaneurysms were seen. The main portal vein, hepatic veins, and mesenteric vein were patent in all cases. An infarct in the right lobe of the liver caused by partial thrombosis of the right hepatic artery associated with right portal branch thrombosis was found in one of the 50 patients (2%). No patient had intrahepatic bile duct dilatation. Pneumobilia was detected in eight of 50 patients (16%); pneumoperitoneum in seven (14%); ascites in 22 (44%); periportal lymphedema in five (10%); pleural effusion or pulmonary atelectasia in 43 (86%); associated pleural and pulmonary involvement in 39 (78%); and pleural effusion or pulmonary atelectasia alone in two patients each (4%).

Discussion

We found a pancreatic fistula in 54% of our patients, a higher percentage than reported by others [4, 8, 13]. Likely explanations for the high incidence of pancreatic fistula in our study are, first, a definition of pancreatic fistula that relies not only on imaging findings but also on clinical and biologic data and, second, inclusion only of patients with a soft pancreas, a well-recognized risk factor for the development of pancreatic fistula [1, 5, 7, 10, 15]. In the surgical literature, terms such as pancreatic leak, pancreatic leakage, and pancreatic fistula are used alternately [17]. We consider the last the most appropriate for indicating failure of healing and sealing of the pancreaticogastric or pancreaticojejunal anastomosis.

The diagnosis of pancreatic fistula classically has been based on clinicobiologic data. Using the definition proposed by the International Study Group on Pancreatic Fistula [11], we made the diagnosis of pancreatic fistula on postoperative day 7 in the cases of 22 of the 27 patients (81%) with pancreatic fistula. This result confirms the high sensitivity (70–75%) of clinical and biologic criteria for the diagnosis of pancreatic fistula reported in the literature [14, 16, 17]. CT performed on postoperative day 7 depicted a perianastomotic collection in 13 of our 22 patients (59%) with overt pancreatic fistula. Although CT had no diagnostic influence in this group of patients, it nevertheless had an influence on therapy.

Despite our results, some occult pancreatic fistulas are initially clinically silent [16]. These fistulas usually are diagnosed after the patient resumes oral intake or after hospital discharge and typically necessitate reoperation or readmission for potentially lethal complications, such as arterial hemorrhage and sepsis [1, 5, 8, 20, 22]. These observations emphasize the importance of accurate screening for occult pancreatic fistula, particularly among patients at high risk. Five of the 50 patients (10%) in this study had a clinically silent pancreatic fistula on postoperative day 7. In these patients, CT revealed a perianastomotic collection suggestive of pancreatic fistula in four of five patients (80%). These results confirm that clinical and biologic criteria alone are not sufficiently reliable in the immediately postoperative period and emphasize the added value of CT [16].

A potential limitation of CT is represented by false-positive diagnoses of pancreatic fistula. In this study, however, we found that true-positive and false-positive perianastomotic collections behaved differently. False-positive perianastomotic collections were smaller (although not significantly); never contained air bubbles; and, most important, had disappeared at follow-up CT in all cases,

unlike perianastomotic collections due to fistula. Because small collections can be difficult to aspirate, we propose considering pancreatic fistula present and maintaining total parenteral nutrition until perianastomotic collections resolve spontaneously.

One of the strengths of our study was that CT was performed on postoperative day 7 for all patients. The interval between surgery and CT was based on observations that the diagnosis of pancreatic fistula is made an average of 7 days after pancreaticoduodenectomy [5, 14, 15]. One study [26] showed that a fluid collection seen around the pancreaticojejunostomy site and in the pancreatic bed on CT images may be caused by pancreatic fistula in patients who have undergone pancreaticoduodenectomy. That study, however, was limited by selection bias: Only patients with clinically suspected complications were included. Moreover, the time between surgery and CT was not uniform, ranging from 4 to 30 days.

Another way to diagnose occult pancreatic fistula may be sinography–fistulography. However, this technique is seldom used and not is recommended on a routine basis for the diagnosis of pancreatic fistula [5, 14, 16, 27]. We did not perform sinography–fistulography to confirm the diagnosis of pancreatic fistula because we believe, as do other authors [28], that the best way to diagnose pancreatic fistula is to closely monitor the output of the drain in the pancreatic bed. Furthermore, fistulography cannot be performed easily with the multichannel open drainage we used. Fistulography may be useful only for planning stepwise mobilization of the drain from the anastomotic area in patients with prolonged placement of an external fistula [17, 29].

CT proved useful in the detection of complications such as portal venous thrombosis and liver complications [22, 30–32]. At CT, we found only one liver complication due to intrahepatic arterial and portal venous thrombosis. We also evaluated expected postoperative changes that must be recognized and differentiated from recurrence of malignant disease. We found perivascular cuffing of mesenteric, celiac, or hepatic vessels and reactive lymph nodes in 28% and 6% of patients, unlike Mortelé et al. [31], who found perivascular abnormalities and reactive lymph nodes in 60% and 32% of patients. A potential explanation for the difference in results may be that the interval between surgery and CT in the study by Mortelé et al. varied from 13 days to 6 years. Periportal lymphedema has rarely been reported after pancreaticoduodenectomy [31]. This finding was observed in 10% of patients in our series and may be explained by early postoperative changes due to extensive lymphatic dissection.

Our study had limitations. First, to our knowledge, there is no consensus in the literature regarding the clinical and biologic criteria for the diagnosis of pancreatic fistula [17]. Amylase level is unanimously considered the principal biologic criterion for a diagnosis of pancreatic fistula, although a reliable cutoff value for absolute amylase activity has not been established, to our knowledge. Drain amylase levels, volume of drain output, and timing of collection in the postoperative course differ considerably among authors [11, 17, 13, 20, 33], and the incidence of pancreatic fistula varies with the definitions used [17]. We adopted the internationally accepted and unifying International Study Group on Pancreatic Fistula criteria [11], which result in higher sensitivity for the detection of pancreatic fistula. Second, most of our patients underwent pancreaticogastrostomy. Although pancreaticojejunostomy is generally used to reconstruct the digestive tract and remnant pancreas, pancreaticogastrostomy has been reintroduced because of the lower incidence of complications in comparison with pancreaticojejunostomy [34]. Third, we included only patients at high risk of pancreatic fistula; therefore, spectrum bias might have been present. Fourth, we reviewed the CT images retrospectively, although all patients systematically underwent CT on postoperative day 7, and CT analysis was made without clinical and biologic information.

We conclude that pancreatic fistula is a frequent complication after pancreaticoduodenectomy among patients with soft pancreas. In these patients, clinical and biologic criteria remain the mainstay of diagnosis. The presence of a perianastomotic collection at CT on postoperative day 7 may be suggestive of but is not conclusive for the diagnosis of pancreatic fistula. In patients at high risk of pancreatic fistula that initially is clinically silent and undetected on the basis of clinical and biologic criteria, CT may be proposed as a complementary diagnostic tool, particularly for detection of clinically occult pancreatic fistula.

References

1. Yeo CJ, Cameron JL, Lillemoe KD, et al. Does prophylactic octreotide decrease the rates of pancreatic fistula and other complications after pancreaticoduodenectomy? Results of a prospective randomized placebo-controlled trial. *Ann Surg* 2000; 232:419–429
2. Sato N, Yamaguchi K, Chijiwa K, Tanaka M. Risk analysis of pancreatic fistula after pancreatic head resection. *Arch Surg* 1998; 133:1094–1098
3. Cullen JJ, Sarr MG, Ilstrup DM. Pancreatic anastomotic leak after pancreaticoduodenectomy: incidence, significance and management. *Am J Surg* 1994; 168:295–298
4. Yeo CJ, Cameron JL, Sohn TA, et al. Six hundred fifty consecutive pancreaticoduodenectomies in the 1990s: pathology, complications and outcomes. *Ann Surg* 1997; 226:248–257
5. Munoz-Bongrand N, Sauvanet A, Denys A, Sibert A, Vilgrain V, Belghiti J. Conservative management of pancreatic fistula after pancreaticoduodenectomy with pancreaticogastrostomy. *J Am Coll Surg* 2004; 199:198–203
6. Muscari F, Suc B, Kirzin S, et al.; French Associations for Surgical Research. Risk factors for mortality and intra-abdominal complications after pancreatoduodenectomy: multivariate analysis in 300 patients. *Surgery* 2006; 139:591–598
7. Böttger T, Junginger T. Factors influencing morbidity and mortality after pancreaticoduodenectomy: critical analysis of 221 resections. *World J Surg* 1999; 23:164–172
8. Aranha GV, Hodul P, Golts E. A comparison of pancreatogastrostomy and pancreaticojejunostomy following pancreaticoduodenectomy. *J Gastrointest Surg* 2003; 7:672–682
9. Peng SY, Wang JW, Lau WY, et al. Conventional versus binding pancreaticojejunostomy after pancreaticoduodenectomy: a prospective randomized trial. *Ann Surg* 2007; 245:692–698
10. Lowy AM, Lee JE, Pisters PW, et al. Prospective, randomized trial of octreotide to prevent pancreatic fistula after pancreaticoduodenectomy for malignant disease. *Ann Surg* 1997; 226:632–641
11. Bassi C, Dervenis C, Butturini G, et al. Postoperative pancreatic fistula: an international study group (ISGPF) definition. *Surgery* 2005; 138:8–13
12. Vanounou T, Pratt WB, Callery MP, Vollmer CM Jr. Selective administration of prophylactic octreotide during pancreaticoduodenectomy: a clinical and cost-benefit analysis in low- and high-risk glands. *J Am Coll Surg* 2007; 205:546–557
13. Hamanaka Y, Nishihara K, Hamasaki T. Pancreatic juice output after pancreatoduodenectomy in relation to pancreatic consistency, duct size and leakage. *Surgery* 1996; 119:281–287
14. Molinari E, Bassi C, Salvia R, et al. Amylase value in drains after pancreatic resection as predictive factor of postoperative pancreatic fistula: results of a prospective study in 137 patients. *Ann Surg* 2007; 246:281–287

15. van Berge Henegouwen MI, De Wit LT, Van Gulik TM, Obertop H, Gouma DJ. Incidence of risk factors and treatment of pancreatic leakage after pancreaticoduodenectomy: drainage versus resection of pancreatic remnant. *J Am Coll Surg* 1997; 185:18–24
16. Pratt WB, Maithrl SK, Vanounou T, Huang ZS, Callery MP, Vollmer CM. Clinical and economical validation of the International Study Group of Pancreatic Fistula (ISGPF) classification scheme. *Ann Surg* 2007; 245:443–451
17. Bassi C, Butturini G, Molinari E, et al. Pancreatic fistula rate after pancreatic resection: the importance of definitions. *Dig Surg* 2004; 21:54–59
18. Reid-Lombardo KM, Farnell MB, Crippa S, et al.; Pancreatic Anastomotic Leak Study Group. Pancreatic anastomotic leakage after pancreaticoduodenectomy in 1,507 patients: a report from the Pancreatic Anastomotic Leak Study Group. *J Gastrointest Surg* 2007; 11:1451–1458
19. Grobmyer SR, Rivadeneira DE, Goodman CA, Mackrell P, Lieberman MD, Daly JM. Pancreatic anastomotic failure after pancreaticoduodenectomy. *Am J Surg* 2000; 180:117–120
20. Conlon KC, Labow D, Leung D, et al. Prospective randomized clinical trial of the value of intraperitoneal drainage after pancreatic resection. *Ann Surg* 2001; 234:487–493
21. Kawai M, Tani M, Terasawa H, et al. Early removal of prophylactic drains reduces the risk of intra-abdominal infections in patients with pancreatic head resection: prospective study for 104 consecutive patients. *Ann Surg* 2006; 244:1–7
22. Lepanto L, Gianfelice D, Déry R, Dagenais M, Lapointe R, Roy A. Postoperative changes, complications and recurrent disease after Whipple's operation: CT features. *AJR* 1994; 163:841–846
23. Klöppel G, Maillet B. Pseudocysts in chronic pancreatitis: a morphological analysis of 57 resection specimens and 9 autopsy pancreata. *Pancreas* 1991; 6:266–274
24. Van Geenen RC, van Gulik TM, Busch OR, de Wit LT, Obertop H, Gouma DJ. Readmission after pancreatectomy. *Br J Surg* 2001; 88:1467–1471
25. Auh YH, Lim JH, Kim KW, Lee DH, Lee MG, Cho KS. Loculated fluid collections in hepatic fissures and recesses: CT appearance and potential pitfalls. *RadioGraphics* 1994; 14:529–540
26. Hashimoto M, Koga M, Ishiyama K, et al. CT features of pancreatic fistula after pancreaticoduodenectomy. *AJR* 2007; 188:975; [web}W323–W327
27. Sarr MG; Pancreatic Surgery Group. The potent somatostatin analogue vapreotide does not decrease pancreas-specific complications after elective pancreatectomy: a prospective, multicenter, double-blinded, randomized, placebo-controlled trial. *J Am Coll Surg* 2003; 196:556–564
28. Tamm EP, Jones B, Yeo CJ, Maher MM, Cameron JL. Pancreaticogastrostomy and the Whipple procedure: radiographic appearance and complications. *Radiology* 1995; 196:251–255
29. Kazanjian KK, Hines OJ, Eibl G, Reber HA. Management of pancreatic fistulas after pancreaticoduodenectomy: results in 437 consecutive patients. *Arch Surg* 2005; 140:849–854
30. Johnson PT, Curry CA, Urban BA, Fishman EK. Spiral CT following the Whipple procedure: distinguishing normal postoperative findings from complications. *J Comput Assist Tomogr* 2002; 26:956–961
31. Mortelé KJ, Lemmerling M, de Hemptinne B, De Vos M, De Bock G, Kunnen M. Postoperative findings following Whipple procedure: determination of prevalence and morphologic abdominal features. *Eur Radiol* 2000; 10:123–128
32. Gervais DA, Fernandez-del Castillo C, O'Neill MJ, Hahn PF, Mueller PR. Complication after pancreaticoduodenectomy: imaging and imaging-guided interventional procedures. *RadioGraphics* 2001; 21:673–690
33. Bruce J, Krukowski H, Al-Khairy G, Russell EM, Park KG. Systematic review of the definition and measurement of anastomotic leak after gastrointestinal surgery. *Br J Surg* 2001; 88:1157–1168
34. McKay A, Mackenzie S, Sutherland FR, et al. Meta-analysis of pancreaticojejunostomy versus pancreaticogastrostomy reconstruction after pancreaticoduodenectomy. *Br J Surg* 2006; 93:929–936