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PICTORIAL ESSAY

Enteric drainage pancreatic transplantation

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Abstract

Enteric drainage is currently the preferred method of pancreatic transplantation. This technique results in long-term good control of diabetes. In this report we discuss the postoperative radiologic anatomy and complications.

Imaging of enteric drainage during pancreatic transplantation

Pancreatic transplantation is the single most effective method of obtaining euglycemic status in diabetic patients. This procedure has been shown to stabilize or reverse complications of diabetes mellitus [1]. The allograft previously was anastomosed to the urinary bladder to allow urinary excretion of exocrine juices. This procedure had frequent and multiple metabolic and urologic complications, including infection, calculi, fistulas, and urethral rupture [2–4]. Enteric drainage of allograft secretion is currently considered the gold standard of pancreatic transplantation [3]. There has been recent interest in the imaging findings of enteric drainage pancreatic transplants [5–7]. In this pictorial review, we present the postoperative anatomy and complications observed in 60 patients who underwent enteric drainage pancreatic transplantation, including several postoperative findings that have hitherto not been reported.

Enteric drainage pancreatic transplantation

The entire cadaver pancreas is transplanted in the lower abdomen through an intraperitoneal approach. In our institution, the portal vein of the pancreatic allograft is anastomosed end-to-side to the recipient right common iliac vein. This technique is termed *systemic enteric drainage* (Fig. 1). In other institutions, portal enteric drainage is performed, i.e., the donor portal vein is anastomosed to the recipient portal vein [8, 9].

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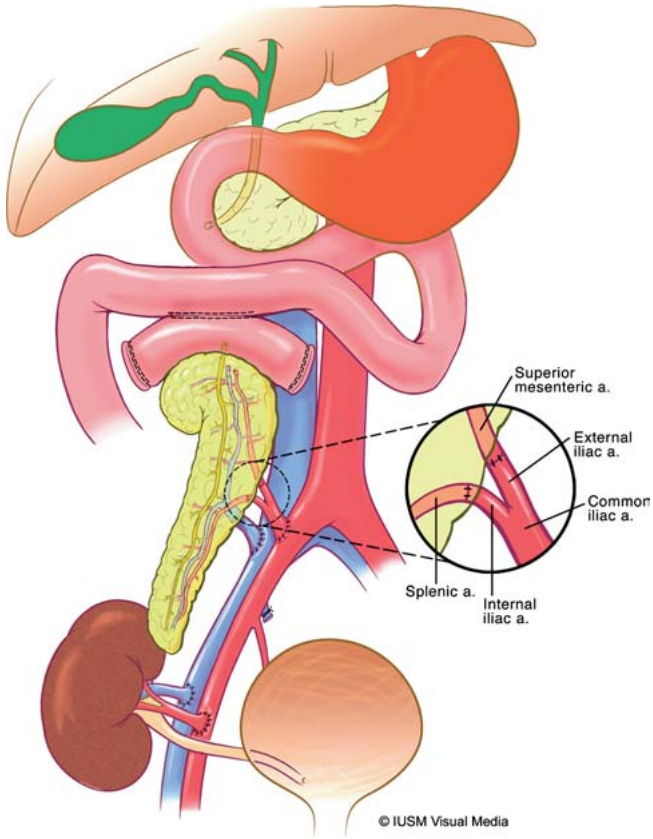

Fig. 1. Line diagram of systemic enteric drainage pancreatic transplant. The donor Y graft is anastomosed to the recipient right common iliac artery. The donor portal vein is anastomosed to the recipient common iliac vein. Enteric anastomosis for exocrine pancreatic drainage is between the donor duodenum and recipient jejunum. Renal artery and vein from the donor kidney are anastomosed to the recipient external iliac artery and vein, respectively. Inset shows construction of the Y graft (using donor vessels) by end-to-end attachment of the splenic to the internal iliac artery and the superior mesenteric to the external iliac artery.

The donor Y graft is anastomosed end-to-side to the recipient right external or common iliac artery. The first to third parts of the donor duodenum is anastomosed side-to-side to the proximal native jejunum.

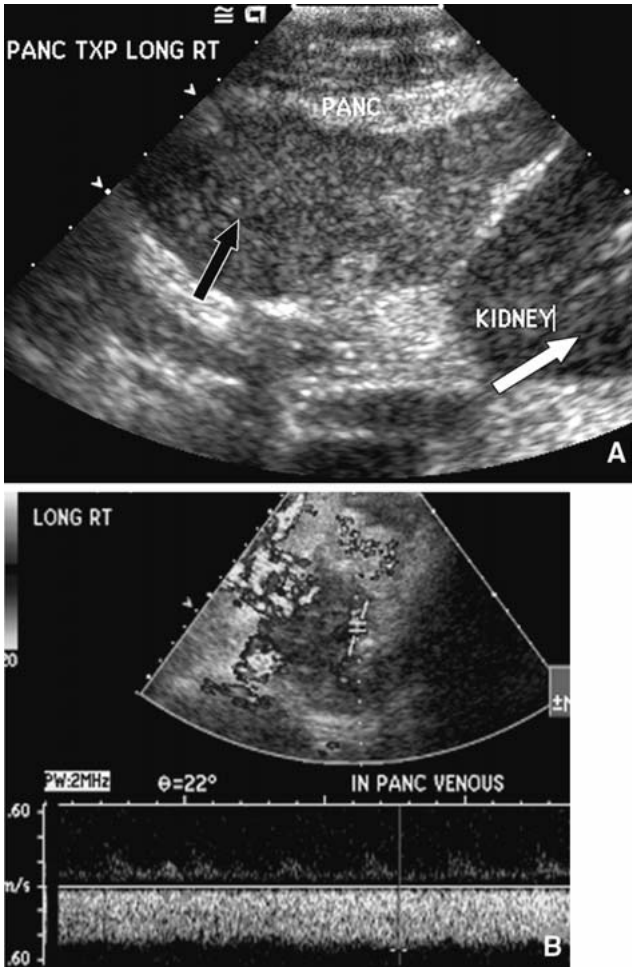

Fig. 2. **A** Normal pancreatic transplant. US of a 39-year-old male 1 day after simultaneous pancreas/kidney transplant shows a normal rounded appearance of the transplanted pancreas (*black arrow*). The pancreas is slightly more echogenic than the adjacent renal transplant (*white arrow*). **B** Doppler US shows normal allograft vein velocity.

Because most pancreatic transplants are performed in older diabetic patients, a simultaneous renal transplant is performed. Occasionally a pancreas-after-kidney transplant is attempted. Rarely an isolated pancreatic transplant is undertaken, such as in patients with cystic fibrosis or young diabetic patients without renal disease.

Postoperative ultrasound findings

Gray-scale and Doppler ultrasound (US) examination of renal and pancreatic transplants are routinely performed at least once in the first 3 postoperative days. In our experience, the pancreatic allograft is not visualized on the initial US scan in about 20% of cases. Given its intraperitoneal location, the allograft may be obscured by bowel. The transplant has homogeneous echotexture, unless there is severe pancreatitis. The echogenicity of the transplant is higher than that of the cortex of the adjacent renal transplant but is lower than that of the native pancreas (Fig. 2). This may be due fatty change in the native organ and the presence of edema in transplants for the first few postoperative days. Velocities and resistive

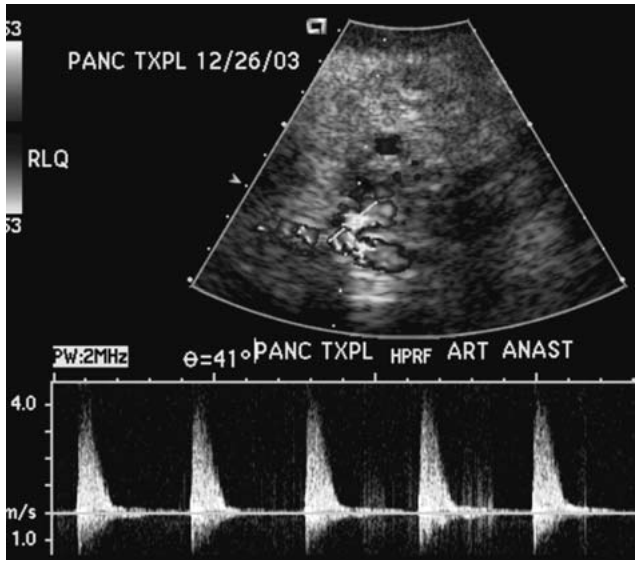

Fig. 3. Doppler study of Y graft at anastomosis shows an arterial velocity of 350 cm/s. The patient had no adverse clinical outcome. On follow-up US (not shown) an anastomotic velocity of about 100 cm/s was noted.

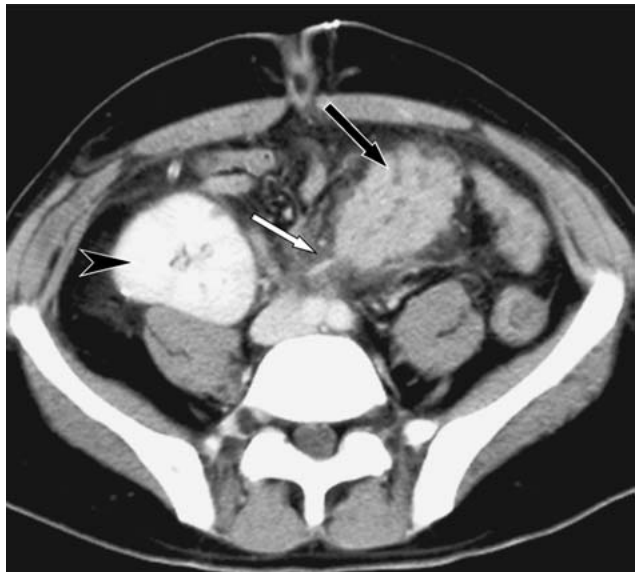

Fig. 4. Axial CT of the lower abdomen in a 46-year-old male on postoperative day 5 shows good enhancement of the pancreatic allograft (*black arrow*), but to lesser degree than the renal transplant (*arrowhead*). Note mild stranding of peripancreatic fat (*white arrow*). This is an almost ubiquitous early postoperative finding and is due to subclinical pancreatitis. The patient did not have abdominal pain but serum amylase was high.

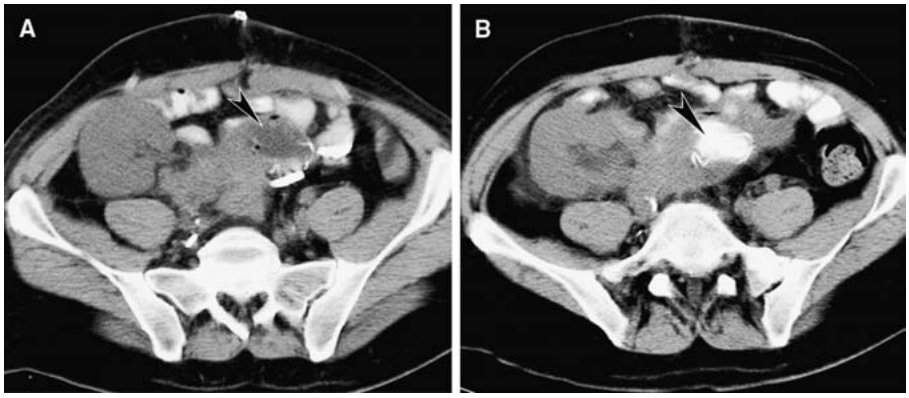

Fig. 5. **A** Axial CT image without intravenous contrast in a 52-year-old male shows "fluid collection" (*arrowhead*) that did not opacify with oral contrast, contained gas bubbles, and was incorrectly interpreted as perigraft abscess. **B** Subsequent CT scan at the same level shows oral contrast within the structure that is surrounded by a ring of staples, confirming a normal donor duodenum (*arrowhead*).

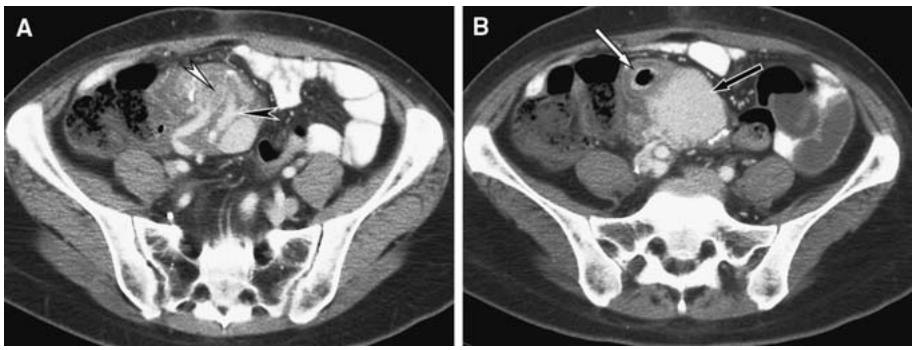

Fig. 6. **A** Axial CT in a 40-year-old female shows a thrombosed donor superior mesenteric artery within the transplant (*white arrowhead*). This is finding is often seen intraoperatively by surgeons and does not affect graft survival. Note the normal donor portal vein (*black arrowhead*). **B** The pancreatic transplant enhances well (*black arrow*). Note the donor duodenum (*white arrow*).

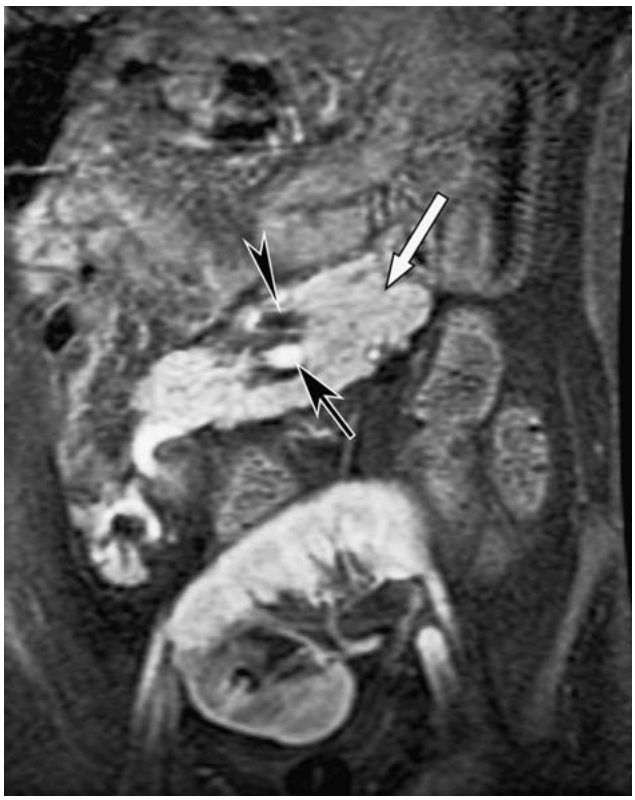

Fig. 7. MRI with gadolinium in a 30-year-old female 6 months after a pancreas-after-kidney transplantation shows thrombosis of the distal donor superior mesenteric artery (*arrowhead*). The portal vein (*black arrow*) and pancreatic transplant (*white arrow*) enhance normally.

indices of pancreatic vessels are routinely measured. Allograft (portal) vein velocities range from 10 to 60 cm/s.

Arterial velocities up to 400 cm/s at the anastomotic site immediately after surgery do not necessarily indicate hemodynamically significant vessel stenosis and often improve on follow-up studies (Fig. 3). Such velocities may be due to anastomotic edema or kinking. In the few patients who had anastomotic stenosis that required angioplasty, the velocity of the donor Y graft at the anastomotic site was faster than 400 cm/s initially or remained faster than 300 cm/s on follow-up studies. Resistive indices of intrapancreatic arteries are typically higher than those in renal transplants and may even be as high as 0.90. The reason for this is not clear but may be related to the almost universal presence of subclinical pancreatitis. Studies on bladder drainage allografts have shown that resistive indices are not specific in determining the presence of acute rejection [10, 11]. Resistive indices also vary through the gland and are generally higher in the tail than in the head.

Postoperative computed tomographic and magnetic resonance imaging findings

Computed tomographic (CT) examinations are requested postoperatively for unexplained fever, abdominal tenderness, or pain. Many of the immediate postoperative examinations are performed with oral but

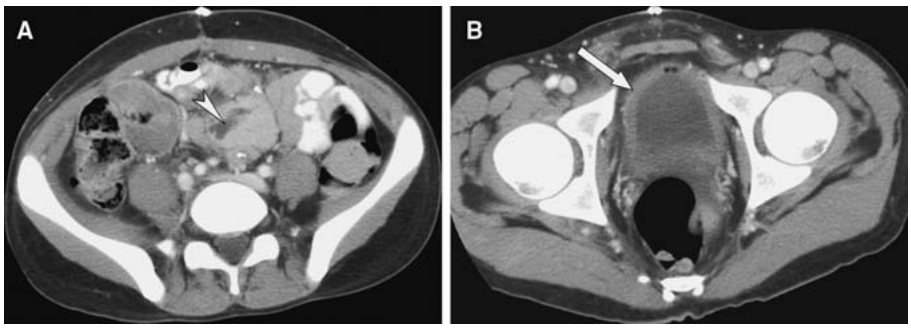

Fig. 8. **A** Axial contrast-enhanced CT of the lower abdomen in a 20-year-old male shows pancreatic duct dilatation (*arrowhead*). There was no clinical pancreatitis at 15-month follow-up. **B** Pelvic image in the same patient shows diffuse wall thickening of the urinary bladder (*arrow*). This is almost universally seen after enteric drainage pancreatic transplants and may be due to irritation from fluid rich in pancreatic enzymes. The gas bubble in the bladder is from catheterization at the time of surgery.

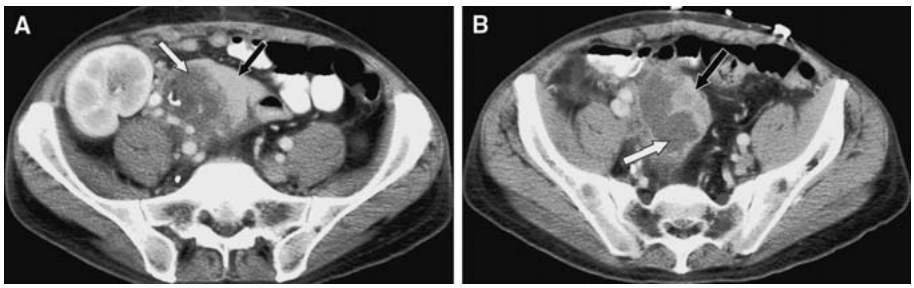

Fig. 9. Axial contrast-enhanced images of the lower abdomen in a 47-year-old male show areas of enhancing (*black arrows*) and necrotic (*white arrows*) in the head (**A**) and tail (**B**) of a transplanted pancreas. The patient eventually recovered from severe necrotic pancreatitis without necrosectomy.

without intravenous contrast, especially in cases of simultaneous renal transplantation. When intravenous contrast is used, we prefer an iso-osmolar agent such as iodixanol (Visipaque, Amersham, Princeton, NJ, USA). If intravenous contrast is required, such as in cases of suspected pancreatic necrosis or vascular occlusion, we use magnetic resonance imaging (MRI) with fat-saturated three-dimensional volumetric dynamic postgadolinium T1-weighted sequence. In other centers, intravenous contrast-enhanced CT may be used more often for assessing postoperative complications.

Many findings are commonly seen after transplantation without adverse outcome on follow-up. The pancreatic transplant often enhances to a lesser degree than the adjacent renal transplant (Fig. 4). Fluid collections are commonly seen around the transplant in the first post-transplant month adjacent to the allograft. The donor duodenum often does not fill with oral contrast. It may be thick walled and simulate a peripancreatic abscess (Fig. 5). Partial or complete occlusion of the donor superior mesenteric artery, distal to its pancreatic branches, is seen in nearly all contrast-enhanced postoperative CT examinations (Figs. 6, 7). This alarming finding did not correlate with subsequent transplant viability and was an expected finding because this artery did not supply the small bowel. Dilation of the main pancreatic duct is often seen and did not correlate with subsequent pancreatitis or rejection (Fig. 8). The dome of the urinary bladder is frequently thick walled for up to 4 weeks and should not be confused for cystitis (Fig. 8). This appearance may be due to irritation of the dome by fluid rich in pancreatic enzymes.

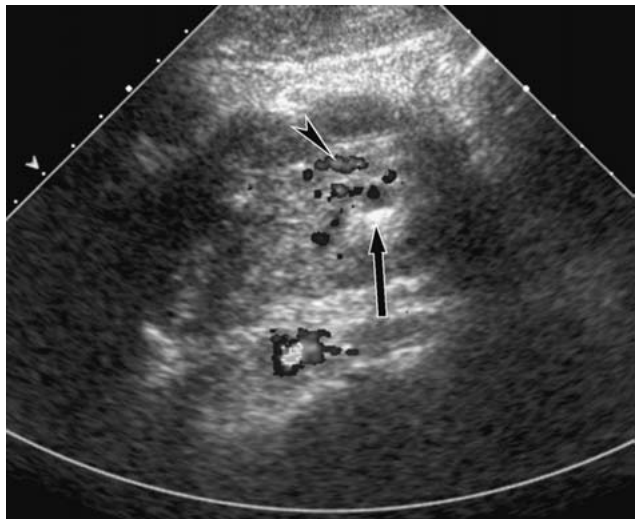

Fig. 10. US of pancreatic allograft in a 39-year-old male shows some arterial color flow (*arrowhead*). No venous flow was detected. There is an echogenic focus (*arrow*) in the transplant that was not seen on US performed 18 hours previously and probably was due to gas bubbles. The transplant was completely necrosed at surgery on the same day.

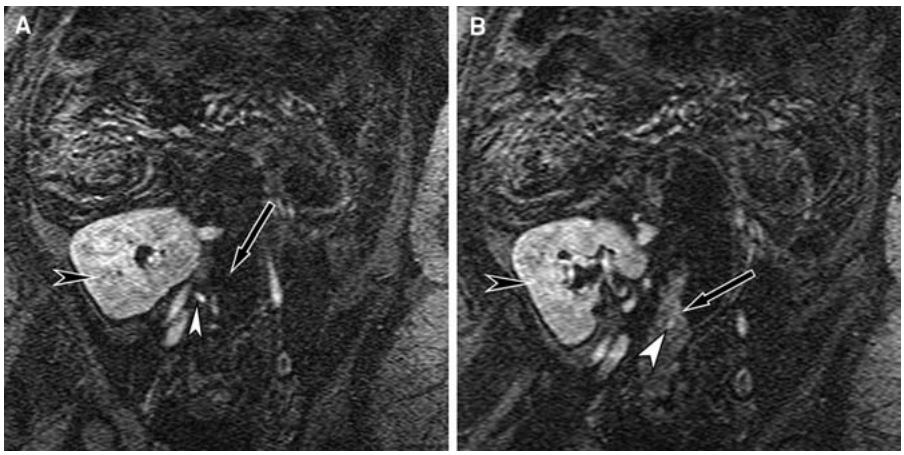

Fig. 11. MR angiograms in late arterial phase show normal enhancement of a renal transplant (*black arrowheads*). **A** The pancreatic head (*black arrow*) does not enhance. **B** The body (*black arrow*) and tail enhance poorly or not at all. These appearances indicate pancreatic necrosis. The pancreatic arterial supply (*white arrowheads*) is intact and necrosis was due to severe pancreatitis.

Complications

Complications are of allograft, bowel, infective, or vascular etiology. Major complications that require surgical intervention are infrequent and seen in about 5% to 10% of cases.

Allograft complications

Early allograft complications include pancreatitis, necrosis, rejection, and fistula. Clinically severe pancreatitis is found in about 10% of allografts [12]. Unless there is necrosis (Fig. 9), seen in about 2% to 4% of allografts, conservative therapy including percutaneous drainage of collections is sufficient. Transplant necrosis can occur not only from pancreatitis but also from primary vascular occlusion. US findings of pancreatic necrosis include lack of arterial and venous flow (Fig. 10) and increased echogenicity that may suggest the presence of gas within transplant. In two cases of transplant necrosis that were encountered, the first US sign was absent venous flow. Gadolinium-enhanced MRI is useful to confirm pancreatic necrosis (Fig. 11).

Pancreatic fistula is commonly seen after several types of pancreatic surgery in which the gland is directly handled. It is less common after transplantation and we have seen only three cases of fistula; the incidence may be low because the allograft is not directly handled during surgery but is positioned by maneuvering the attached donor spleen, which is subsequently removed.

Acute rejection is much less common in pancreatic transplantation that in renal transplantation. The diagnosis is made clinically and by surgical biopsy. Percutaneous biopsy is possible but may be difficult because of the location of the transplant. Occasionally there is concern that the graft failure is due to technical factors, such as vascular occlusion, instead of rejection or pancreatic necrosis. In these circumstances, contrast-enhanced gadolinium dynamic MRI is useful.

Post-transplant lymphoproliferative disease (PTLD) is a rare long-term complication of transplantation. The predominant radiologic finding of PTLD in pancreatic transplant recipients is diffuse allograft enlargement, an appearance that may be indistinguishable from that of acute pancreatitis or transplant rejection [13]. However, failure of response to immunosuppressive therapy, presence of focal masses in or around the graft, or organomegaly may point toward the diagnosis of PTLD. The reported incidence of PTLD after pancreatic transplants is about 3% to 12% [14, 15]. However, we have not seen this complication in 12 to 24 months of follow-up of 60 patients. This difference may be explained by the type of immunosuppressant regime employed.

Bowel complications

Bowel complications after any abdominal surgery include small bowel obstruction and leak. There are several causes of postoperative small bowel obstruction including adhesions, internal and external hernia, anastomotic stenosis, intussusception, marginal ulcers, and obturation. In our experience, adhesions and internal hernia (Fig. 12) are the commonest causes of post-transplant obstruction, being seen in three and two of 60 patients, respectively. Conventional CT or CT enteroclysis is used to diagnose the site, cause, and degree of small bowel obstruction and complications such as strangulation.

Anastomotic leaks are better assessed with CT enteroclysis than with conventional CT. Extravasation of orally introduced contrast is diagnostic.

Vascular complications

Anastomotic stenosis and pseudoaneurysm are infrequent complications of transplantation. Vascular stenosis may be shown by CT or MR arteriography. Pseudoaneurysm is a rare complication of pancreatic transplantations and may be related to surgical tech-

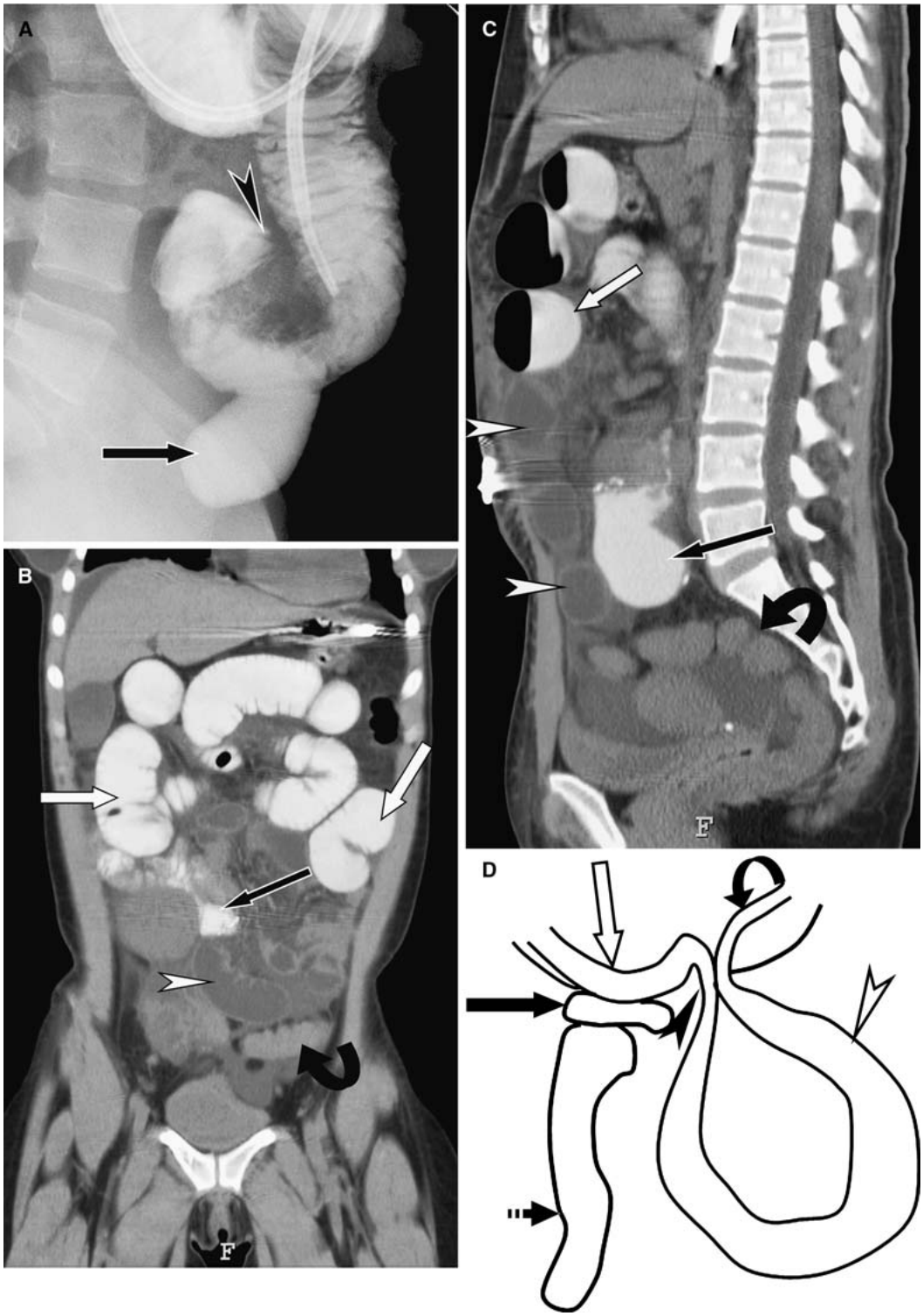

Fig. 12. **A** Fluoroscopic part of CT enteroclysis in a 29-year-old female shows a beaked end at the site of small bowel obstruction (*black arrowhead*). The donor duodenum (*black arrow*) is attached to the jejunum proximal to obstruction. Reformats in coronal (**B**) and sagittal (**C**) planes of isotropically acquired CT enteroclysis show a contrast-filled, distended, proximal jejunum (*white arrows*). Note the more distal distended bowel loops (*white arrowheads*) in radial configuration that is not opacified with oral contrast. Pelvic small bowel loops are nondistended (*curved arrows*). This indicates obstruction at two sites, most likely in the close loop. Internal hernia, through a mesenteric defect created at the time of surgery, was noted at same-day surgery (donor duodenum, *black arrows*). **D** Line diagram shows the anatomy of an internal hernia. Note that internal hernia occurs through the mesenteric defect used to attach the donor duodenum to the recipient jejunum (pancreatic transplant, *dashed black arrow*). Other legends are as for images A to C.

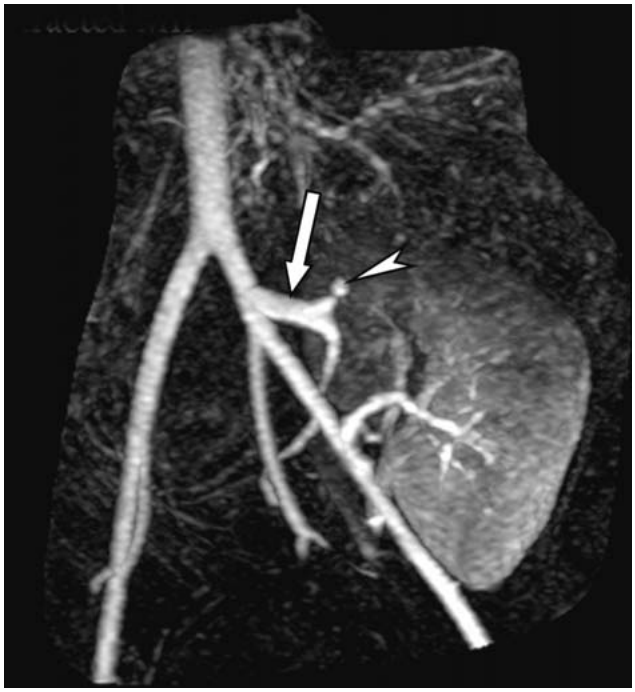

Fig. 13. Subtracted coronal MR angiogram in a 49-year-old female shows a pseudoaneurysm (*arrowhead*) arising from the donor Y graft (*arrow*). The patient had severe necrotic pancreatitis with a probable etiology of a pseudoaneurysm.

nique, infection (mycotic aneurysm), severe pancreatitis (Fig. 13), or allograft biopsy. Most reported pseudoaneurysms originate from the site of the vascular anastomosis. Postoperative hemorrhage is a potential complication that can be diagnosed by CT or MRI. Fistula between the arterial graft and donor duodenum has been reported to be a source of major gastrointestinal bleeding that can be successfully treated with coil embolization [16].

Infective complications

Abscess may complicate a pseudocyst or an anastomotic leak. These are usually treated by antibiotics and percutaneous drainage. Generalized peritonitis is less common and requires surgical intervention (Fig. 14). Pseudomembranous or cytomegaloviral colitis is occasionally seen after transplantation and the diagnosis of colitis may sometimes be initially made on CT.

Conclusion

The enteric drainage technique is the preferred surgical approach for pancreatic transplantation. The transplant surgeon relies on imaging to diagnose potentially serious complications. The radiologist must be aware of the postoperative anatomy and expected CT or US findings to avoid misinterpreting these for postoperative compli-

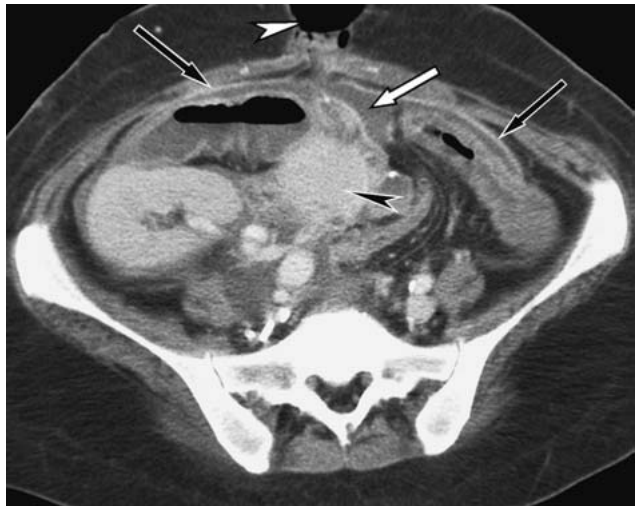

Fig. 14. A 34-year-old female whose postoperative course was complicated by bacterial peritonitis that required repeat surgery. Axial CT image shows peritoneal thickening and enhancement (*black arrows*) with dense ascites (*white arrow*). An open anterior wound is visible (*white arrowhead*). Pancreatic transplant enhances normally (*black arrowhead*).

cations. Increasingly MRI is used to diagnose pancreatissssc and vascular complications, although CT remains the imaging procedure of choice for assessing infective and bowel-related complications.

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