Chapter 6
Pancreas Transplantation

Temel Tirkes and Kumaresan Sandrasegaran

Abbreviations

CT	Computerized tomography
MRI	Magnetic resonance imaging
US	Ultrasonography

Introduction

More than 30,000 pancreas transplants have been reported to the International Pancreas Transplant Registry from 1966 to 2008. Approximately 22,000 were from the USA [1, 2]. Pancreatic transplantation offers the potential for normalization of blood sugar levels in patients with diabetes mellitus. The procedure helps to stabilize or reverse many of the complications associated with diabetes, such as neuropathy, and improves quality of life.

Although pancreas transplantation has even been performed sporadically in patients with type 2 diabetes, this disease is not yet accepted to be a proven indication for pancreas transplantation [3]. Simultaneous pancreas-kidney transplantation is considered a life-saving therapy for patients with type 1 diabetes and concomitant end-stage kidney disease [4, 5]. Pancreas after kidney transplantation is performed in lower numbers. Rarely an isolated pancreatic transplant is undertaken, such as in patients with cystic fibrosis or young diabetic patients without renal disease. Complications are of allograft, bowel, infective, or vascular etiology. Major complications that require surgical intervention are infrequent and seen in about 5–10% of cases. Early allograft complications include pancreatitis, necrosis, rejection, and fistula. Clinically severe pancreatitis is found in about 10% of allografts [6].

T. Tirkes, M.D. (✉) · K. Sandrasegaran, M.D.
Department of Radiology and Imaging Sciences, Indiana University School of Medicine, Indianapolis, IN, USA
e-mail: atirkes@iupui.edu; ksandras@iupui.edu

G. Fananapazir, R. Lamba (eds.), *Transplantation Imaging*,
https://doi.org/10.1007/978-3-319-75266-2_6

Anatomic Considerations

Pancreas transplantation is usually performed using the whole organ with a concomitant duodenal patch. Transplantation of a segmental pancreas or the gland with only a small duodenal fragment is of historical interest and no longer used. The following surgical options are available for pancreas transplant [7]:

- Arterial anastomosis
  - Vascular reconstruction with donor iliac Y graft (splenic artery—internal iliac artery, superior mesenteric artery—external iliac artery)
  - Aortic patch of the celiac trunk and superior mesenteric artery
- Portal venous anastomosis
  - Systemic—venous (vena cava)
  - Portal—venous (branch of mesenteric vein)
- Exocrine drainage
  - Enteric (small bowel or duodenum)
  - Bladder

The different techniques can be mixed with one exclusion: bladder drainage cannot be performed with portal venous drainage owing to technical factors. Placement of the pancreas graft can be head-down or head-up. The pancreas graft can be placed intraperitoneally or retroperitoneally behind the right colon [8].

Surgical Techniques

Systemic Enteric Drainage

This is the most frequently used technique worldwide (85% enteric drainage, 79% systemic venous) [1]. Enteric exocrine drainage is performed using a staple technique, in which the donor duodenum is anastomosed side to side to native jejunum, 30–40 cm distal to the ligament of Treitz [9]. The portal vein of the pancreatic allograft is anastomosed to the recipient right external iliac vein. The donor common iliac artery is anastomosed to the recipient right external iliac artery (Fig. 6.1). The use of direct anastomosis is currently prevalent over Roux-en-Y loop [8]. Duodeno-duodenostomy is a further option when the pancreas is placed in the right retrocolic space [8]. This technique allows endoscopic surveillance but entails challenging repair of the recipient's duodenum in the case of allograft pancreatectomy.

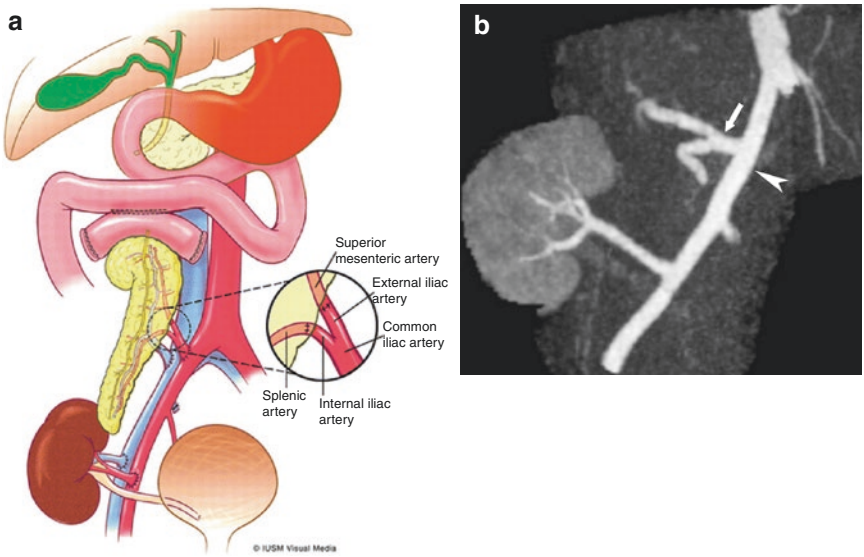

Fig. 6.1 (**a**) This illustration shows the systemic enteric drainage pancreatic transplant. The donor Y graft is anastomosed to the recipient right common iliac artery. The donor portal vein is anastomosed to the recipient common iliac vein. Enteric anastomosis for exocrine pancreatic drainage is between 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. (**b**) This coronal reconstructed image of MR angiography is from a patient who is status post renal and pancreas transplantation. Arrowhead is pointing to the right common iliac artery and the arrow points to the trunk of the Y graft

Systemic Bladder Drainage

Bladder drainage helped make pancreas transplantation a routine and frequent procedure [10]. Until recently, bladder drainage was associated with a significantly lower technical failure rate according to the International Pancreas Transplant Registry data. The drainage of the exocrine secretion into the bladder allows the possibility of monitoring the graft function by measuring the amount (not concentration) of amylase secretion in the urine in 24 h. However, owing to new immunosuppressive protocols and a reduction in rejection episodes, even for these procedures enteric drainage is favored today.

Portal Enteric Drainage

Portal venous drainage has become popular since the mid-1990s when the technique was described by Gaber et al. [11]. As these methods place the pancreas graft in a mid-abdominal position, arterial anastomosis may be difficult. The physiological secretion of the insulin with a first pass through the liver (in contrast to a permanent hyperinsulinemia of the systemic venous drainage) is assumed to be beneficial. However, there is no proof of a beneficial metabolic effect of the portal venous drainage compared with systemic venous drainage.

Imaging Modalities

The radiologist must be aware of the postoperative anatomy and expected CT or US findings to avoid misinterpreting these for postoperative complications. Increasingly MRI is used to diagnose pancreatic and vascular complications, although CT remains the imaging procedure of choice for assessing infective and bowel-related complications.

Ultrasound

Gray-scale and Doppler ultrasound (US) examination of renal and pancreatic transplant are routinely performed at least once in the first three postoperative days (Fig. 6.2). The pancreatic allograft may not be visualized on the initial US scan, since the allograft may be obscured by bowel. The transplant should have a homogeneous echotexture, unless there is severe pancreatitis. The echogenicity of the pancreas transplant is higher than that of the cortex of the adjacent renal transplant but is lower than that of the native pancreas. This may be due to fatty change in the native organ and the presence of edema in transplants for the first few postoperative days. Filling of the urinary bladder may help ultrasonic visualization of the allograft (Fig. 6.3). Velocities and resistive indices of pancreatic vessels are routinely measured. Allograft (portal) vein velocities range from 10 to 60 cm/s.

Elevated arterial velocities at the anastomotic site immediately after surgery do not necessarily indicate hemodynamically significant vessel stenosis and often improve on follow-up studies. 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 intra-pancreatic 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

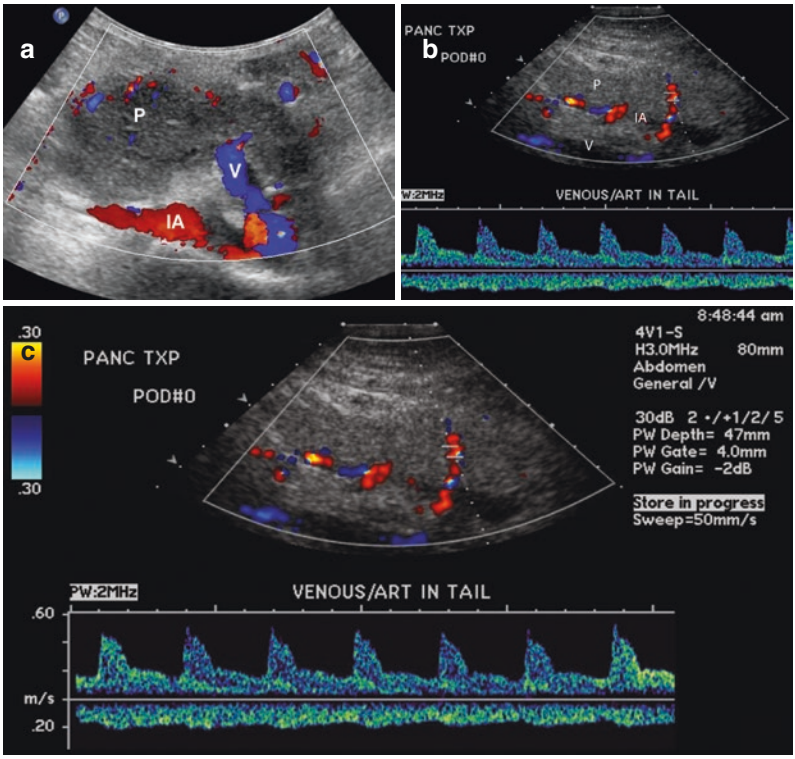

Fig. 6.2 (**a**) Doppler image of the pancreas transplant (P), iliac artery (IA), and transplant vein (V). (**b**) Doppler interrogation of the pancreatic tail demonstrating mixed arterial and venous flow. Patency of the transplant vessels is usually evaluated by ultrasound in the immediate postoperative period

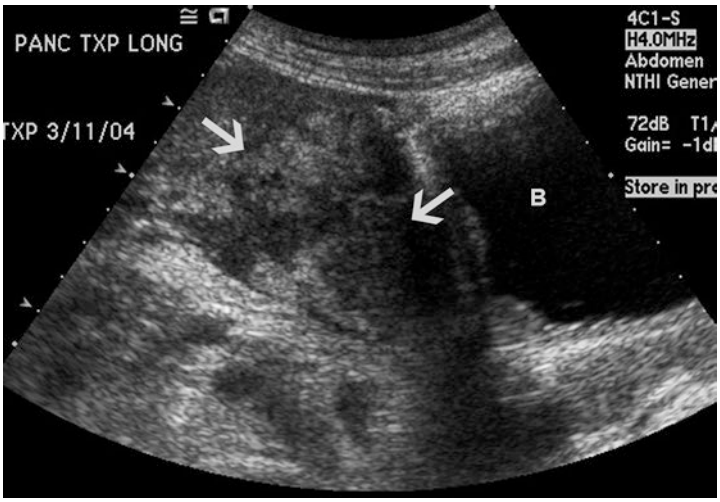

Fig. 6.3 Sagittal ultrasound image of the pelvis showing inhomogeneous echotexture of the pancreas transplant (arrows) due to acute pancreatitis. Distended bladder (B) may help visualization of the transplant

allografts have shown that resistive indices are not specific in determining the presence of acute rejection [12, 13]. Resistive indices also vary through the gland and are generally higher in the tail than in the head.

Computed Tomography

Computed tomographic (CT) examinations are usually requested for unexplained postoperative fever, abdominal tenderness, or pain. Many of the immediate postoperative examinations are performed with oral but without intravenous contrast, especially in cases of simultaneous renal transplantation. If vascular disease or transplant necrosis is suspected, Doppler sonography or gadolinium-enhanced MRI examination is typically performed. In some centers, intravenous contrast-enhanced CT with low iodinated contrast dose 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. 6.4). It is not uncommon to see fluid collections around the transplant in the first posttransplant month adjacent to the allograft (Fig. 6.5). Partial or complete occlusion of the donor superior mesenteric artery or vein, distal to its pancreatic branches, is seen in nearly all contrast-enhanced postoperative CT examinations (Fig. 6.6). This alarming finding does not correlate with subsequent transplant viability and may be expected since the donor artery does not supply the small bowel. The donor duodenum often does not fill with oral contrast.

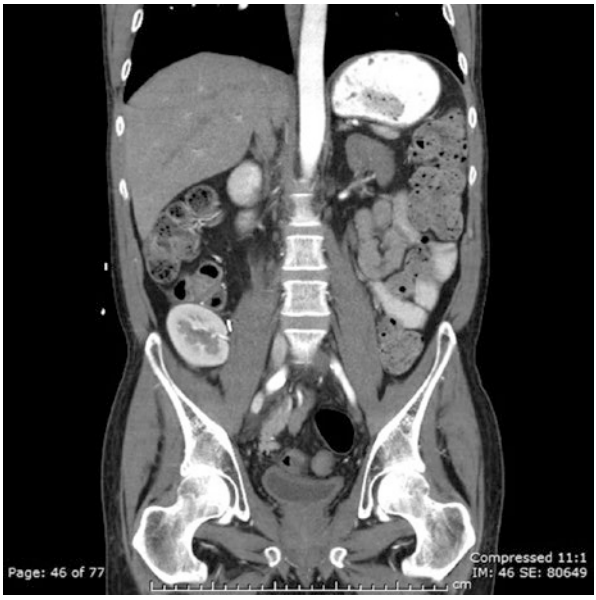

Fig. 6.4 Axial post-contrast CT of the pelvis showing the transplant kidney (black arrow) in the left iliac fossa and transplant pancreas in the midline (white arrow). It is normal for the pancreas to enhance less than the kidney. Pancreatic vasculature is patent (arrowhead)

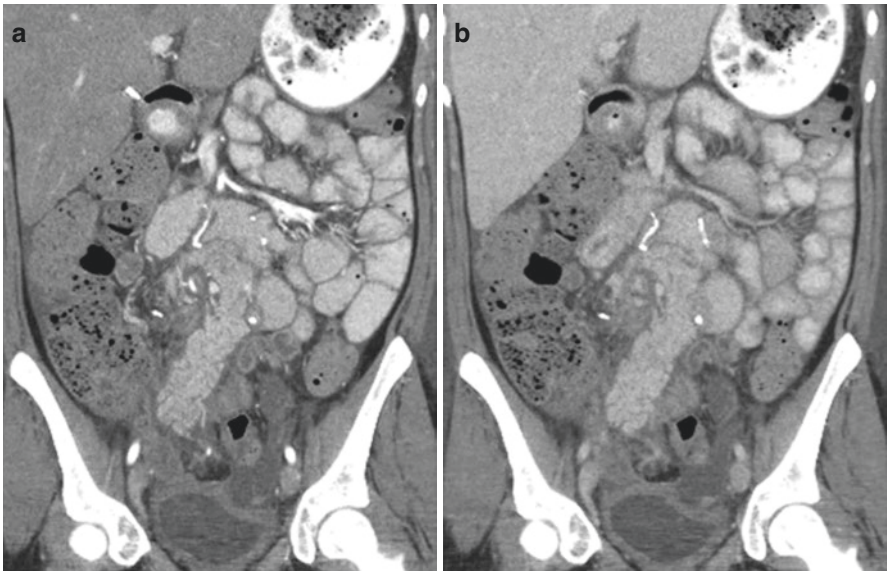

Fig. 6.5 Coronal reformatted contrast-enhanced CT of the pancreas transplant. There is small amount of fluid surrounding the pancreas (arrows)

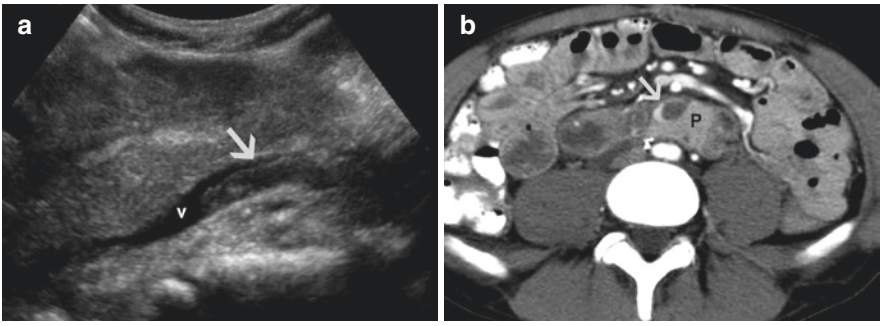

Fig. 6.6 (**a**) Gray-scale ultrasound of the pancreas transplant shows a non-occlusive thrombus (arrow) within the transplant vein (v). (**b**) Axial contrast-enhanced CT of the transplant pancreas shows a non-occlusive thrombus within the graft vein

It may be thick-walled and simulate a peripancreatic abscess (Fig. 6.7). Dilation of the main pancreatic duct is often seen and does not correlate with subsequent pancreatitis or rejection. The dome of the urinary bladder is frequently thick-walled for up to 4 weeks and should not be confused for cystitis (Fig. 6.8). This appearance may be due to irritation of the dome by fluid-rich pancreatic enzymes.

Magnetic Resonance Imaging (MRI)

MRI has been shown to be very valuable and accurate for evaluation of pancreatic transplant complications [14]. However, MRI is usually not the primary imaging modality for evaluating the complications of pancreas allograft but instead reserved for the cases

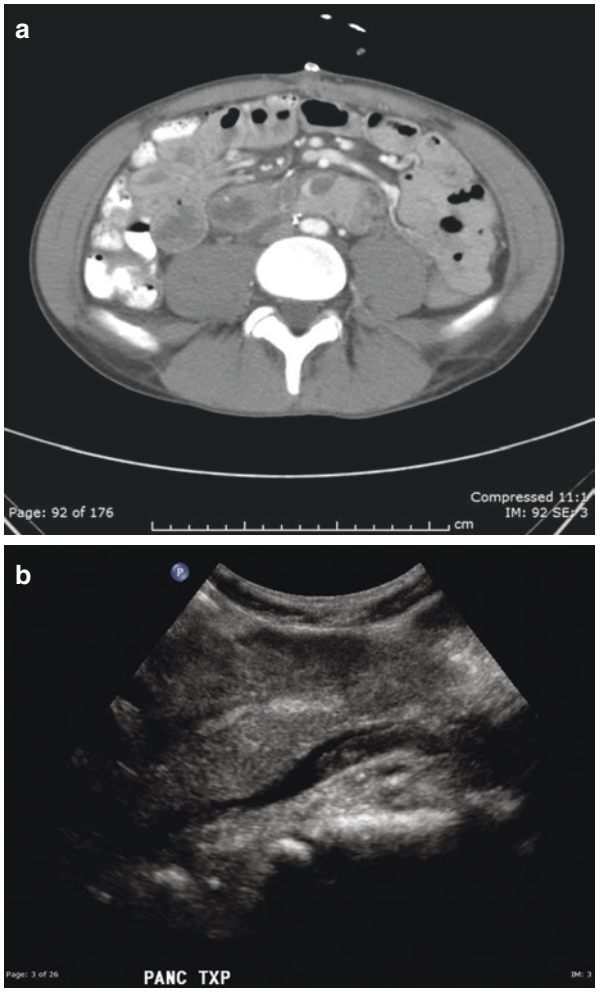

Fig. 6.7 (**a**) Axial CT image without IV contrast shows transplant kidney (K) and donor duodenum (arrows). Enteric contrast was given prior to this examination but did not fill in the duodenum. This appearance of the donor duodenum can mimic an abscess. (**b**) Coronal reformatted contrast-enhanced CT of the pancreas transplant (P). If the donor duodenum does not fill with enteric contrast, it can mimic a pretransplant collection

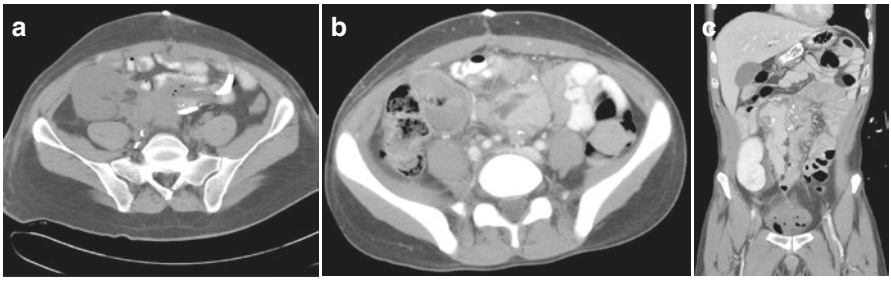

Fig. 6.8 Coronal contrast-enhanced CT image shows transplant kidney (K) and pancreas (P). Urinary bladder (B) shows wall thickening and perivesicular fat stranding (arrows) which can be seen following pancreas transplants

that could not be adequately evaluated by US or CT. MRI can be helpful to identify a fluid collection and distinguish it from a hematoma by detecting T1 hyperintensity. MRCP of the transplant pancreas can be performed to identify the anatomy of the pancreatic duct and status of the anastomosis. MRCP with IV secretin can be helpful to demonstrate exocrine function related to complications of pancreas allograft. Heverhagen et al. found that 10 min after IV secretin infusion, fluid excretion should be greater than 100 mL [15]. However, more studies are needed to evaluate value of secretin during MRCP for allograft evaluation. MRA was found to be a reliable imaging technique to identify vascular complications such as occlusion, stenosis, and infarction [16].

Vascular Complications

Vascular complications include thrombosis, pseudoaneurysm, and arterial extravasation.

Graft Thrombosis

Thrombosis of the graft portal vein or splenic vein are still the most frequent serious surgical complications, with an incidence of up to 10% [1, 17]. Clinical symptoms of pancreas graft thrombosis include sudden onset of otherwise unexplained hyperglycemia. Diagnosis of pancreas graft thrombosis may be established by imaging studies such as Doppler ultrasound, CT angiography, conventional angiography, or magnetic resonance imaging. Absent or reversed arterial diastolic low with Doppler US evaluation of pancreas transplants in the postoperative period is strongly associated with subsequent transplant failure, particularly in the setting of concurrent splenic vein thrombus [18]. With rare exceptions it results in the need for relaparotomy and transplant pancreatectomy [17]. Thus, graft thrombosis is the most frequent cause of early graft loss following pancreas transplantation. Early ultrasonic

findings include lack of venous flow in the allograft. Arterial flow may be preserved in early graft venous thrombosis (Fig. 6.9). The glandular echogenicity becomes heterogeneous. If unrecognized, graft venous thrombosis may lead to complete glandular necrosis (Fig. 6.10). Arterial thrombosis occurs less frequently and may be due to surgical technique or kinking of the Y graft. If recognized early, repositioning of the allograft, arterial stenting, or thrombectomy may help preserve the transplant.

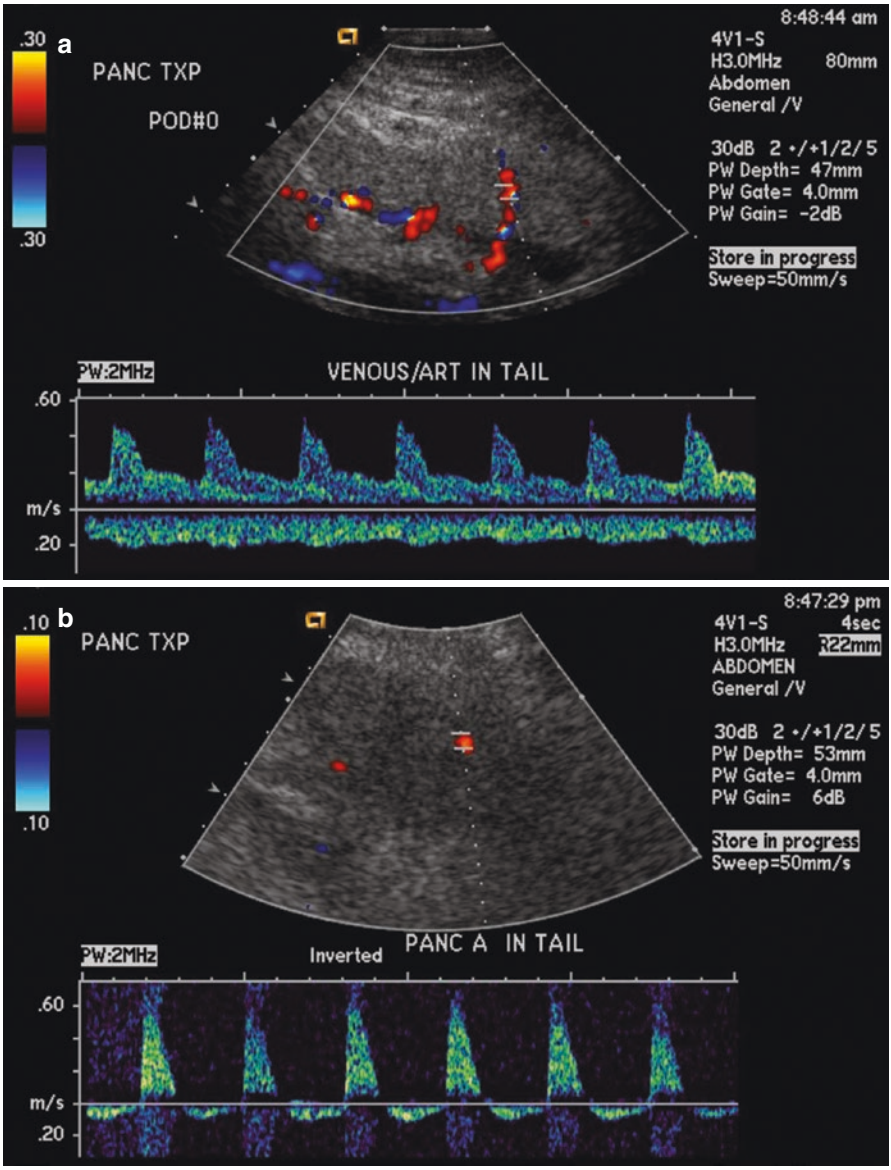

Fig. 6.9 Doppler ultrasound of the pancreas transplant (P) shows lack of venous flow (arrow) in the presence of arterial supply

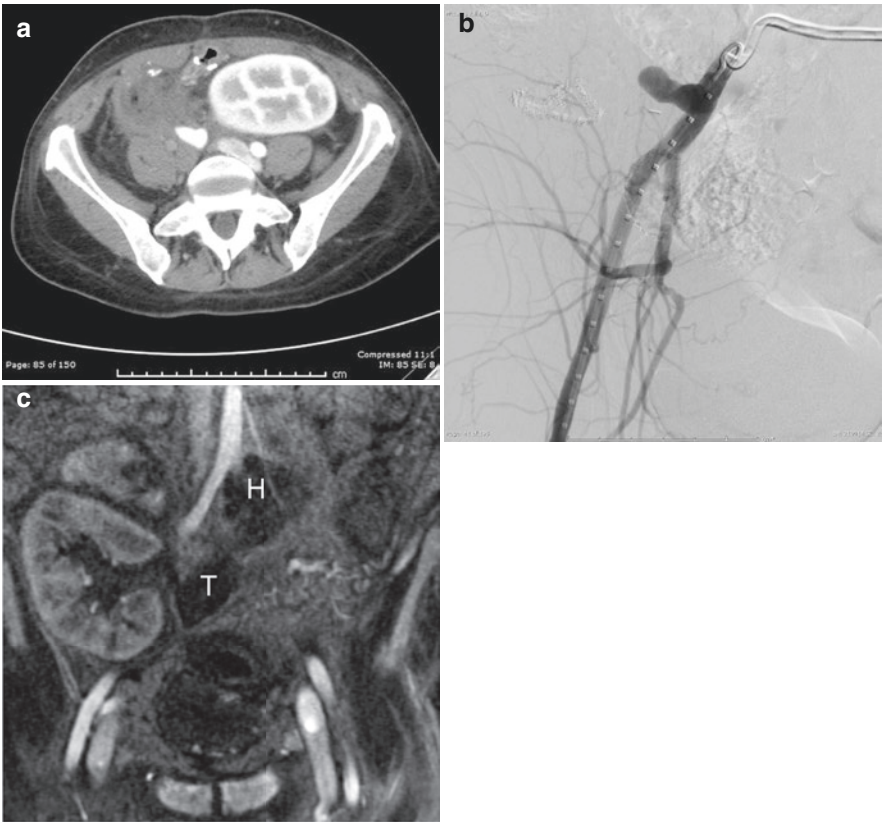

Fig. 6.10 (**a**) Axial contrast-enhanced CT of the kidney transplant in the left iliac fossa. There is complete occlusion of the transplant artery (black arrow) causing non-enhancing heterogeneous transplant pancreas (P). If undetected early, this results in transplant necrosis. (**b**) Conventional arteriogram of the iliac artery shows complete occlusion of the Y graft (arrow). (**c**) Coronal MR angiography image of the pelvis during arterial phase shows no enhancement within the head (H) and tail (T) of the pancreas transplant

Stenosis and Pseudoaneurysm

Anastomotic stenosis and pseudoaneurysm are infrequent complications of transplantation. Most pseudoaneurysms originate from the site of the vascular anastomosis. CT or MR arteriography may show vascular stenosis. Pseudoaneurysm is a rare complication of pancreatic transplantations and may be related to surgical technique, infection (mycotic aneurysm), severe pancreatitis (Fig. 6.11), or allograft biopsy.

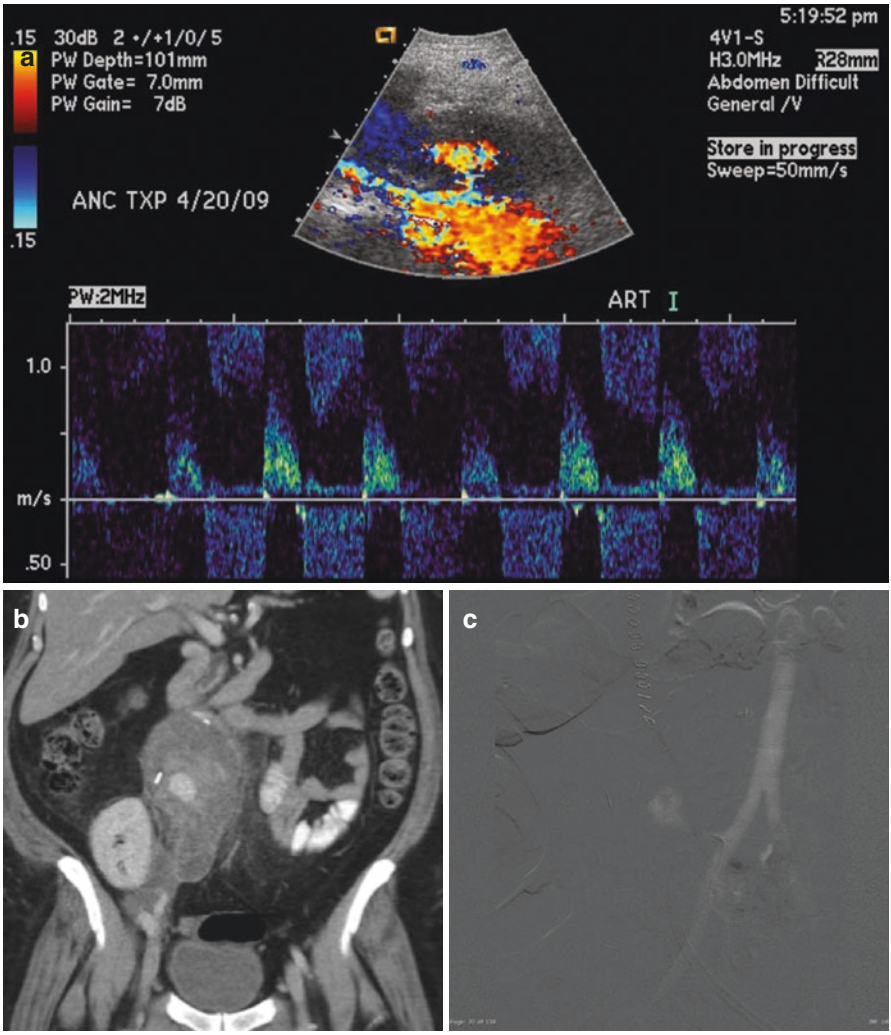

Fig. 6.11 (**a**) Doppler ultrasound image of the transplant artery shows a pseudoaneurysm (arrow). There is to-and-fro flow within the neck of the pseudoaneurysm. (**b**) Coronal reformat of the contrast-enhanced CT shows the pseudoaneurysm of the transplant pancreas artery (arrow). (**c**) This is an image from CO2 angiography. This is a pseudoaneurysm (arrow) arising from the Y graft of the pancreas transplant

Parenchymal Complications

These complications include pancreatitis, allograft necrosis, pancreatic abscess, acute graft rejection, acute graft-versus-host disease, and posttransplant lymphoproliferative disorder.

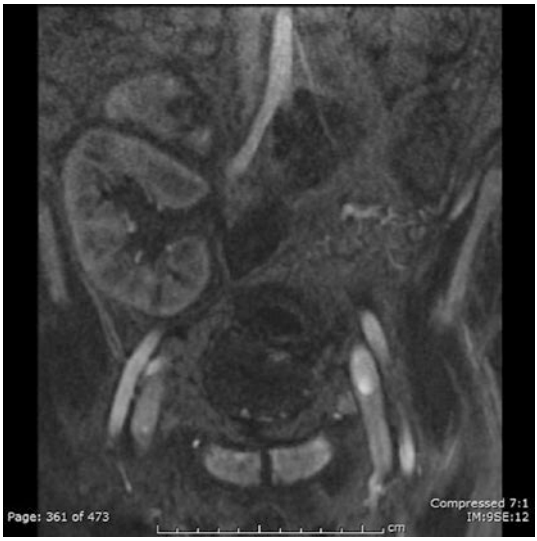

Fig. 6.12 Axial contrast-enhanced CT of the pelvis shows poor enhancement of the pancreas transplant (P). There is peripancreatic loculated fluid collection (arrow) being managed by a percutaneous drainage tube (long arrow)

Graft Pancreatitis and Related Complications

Like native pancreatitis, graft pancreatitis can be mild or severe with necrosis. Peripancreatic fluid collections can be infected and develop into an abscess or a pseudocyst (Fig. 6.12). Unless there is necrosis, conservative therapy including percutaneous drainage of collections is sufficient. The decision for re-laparotomy depends on the clinical appearance (signs of peritonitis) and laboratory results (C-reactive protein, leucocytes, amylase, lipase). A pancreatic abscess may also occur secondary to anastomotic leaks and following acute rejection (Fig. 6.13).

Acute Graft Rejection

Acute rejection is much less common in pancreatic transplantation that in renal transplantation. The diagnosis is made clinically and by surgical biopsy (Fig. 6.14). Percutaneous biopsy is possible but may be difficult because of the location of the transplant behind loops of bowel.

Posttransplant Lymphoproliferative Disease (PTLD)

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 [19]. This topic will be discussed in another chapter.

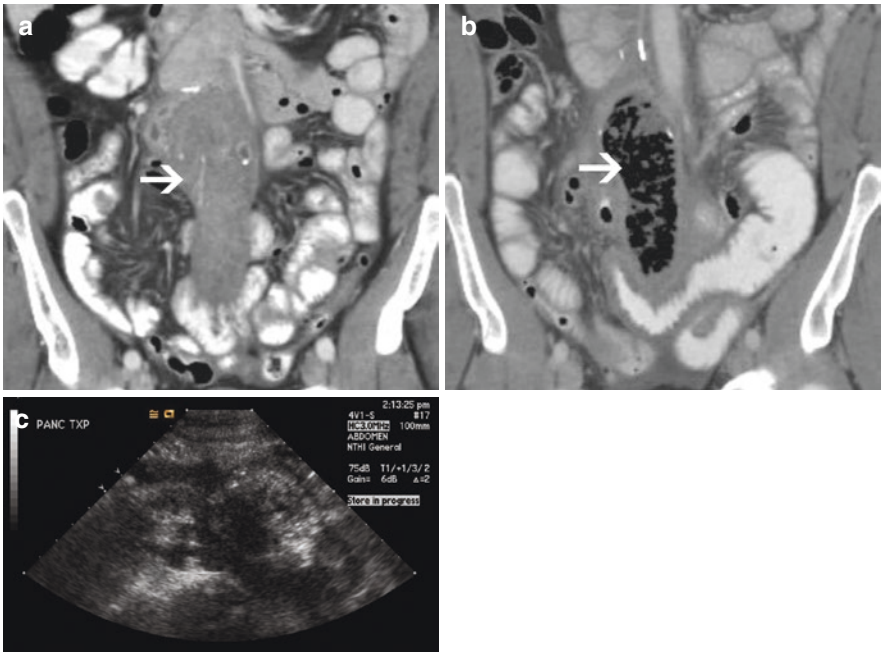

Fig. 6.13 (**a**) Coronal CT image of the pancreas (arrow) showing diffuse edema of the graft parenchyma secondary to acute rejection. (**b**) Subsequent contrast-enhanced CT study in the same patient with acute rejection shows complete necrosis of the pancreas transplant. The necrotic cavity was filled with air (arrow)

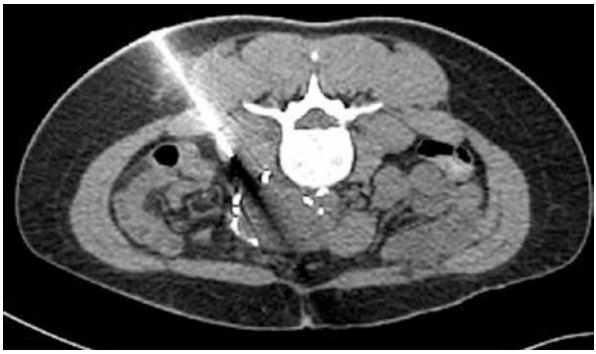

Fig. 6.14 This is a CT image during a percutaneous biopsy of the transplant pancreas (P) in a patient being evaluated for with graft rejection

Bowel Complications

Bowel-related complications include bowel obstruction, anastomotic leak, bowel fistula, and posttreatment infections, such as due to *Clostridium difficile.*

Small Bowel Obstruction

There are several causes of postoperative small bowel obstruction including adhesions, internal and external hernia, anastomotic stenosis, obturation by bezoar, and intussusception. Adhesions are the most common etiology of bowel obstruction. Intraperitoneal placement of the pancreas allograft creates the potential for internal hernia and bowel strangulation (Fig. 6.15). The mesenteric defect after this transplantation is defined by the aorta and iliac artery posteriorly, the small-bowel mesentery superiorly, the pancreas and enteric anastomosis anteriorly, and the pancreatic vascular anastomoses inferiorly. Jejunum adjacent to the anastomosis with donor duodenum may become trapped posteriorly in relation to the pancreas transplant. In cases of adhesive obstruction, unlike with an internal hernia, distended loops may not be seen posteriorly in relation to the donor duodenum [20]. It is important to make a timely diagnosis of an internal hernia, which is a closed-loop obstruction. The rate of strangulation is much higher than with an adhesion-related small bowel obstruction [21]. Conventional CT or CT enteroclysis can be used to diagnose the site, cause, and degree of small bowel obstruction and complications such as strangulation.

Anastomotic Leak

Anastomotic leaks occur rarely but remain a clinically significant entity, as they are a risk factor for intra-abdominal infection. The impact on graft and patient survival is minimal if leaks are recognized early and managed properly. As clinical appearance and therapeutic options are different, it is important to distinguish leaks in enteric and bladder-drained grafts. Recipients of enteric drained grafts develop early peritonitis and sepsis due to spillage of enteric contents. Abdominal CT can be obtained with oral contrast to confirm the diagnosis. Generalized peritonitis is less common and requires surgical intervention. Treatment consists of re-laparotomy with anastomotic revision or even transplant pancreatectomy.

Peri-transplant Collections

Abscess may complicate an anastomotic leak and is usually treated by antibiotics and percutaneous drainage. Like native pancreatitis, graft pancreatitis can range from mild to severe with necrosis. Peripancreatic fluid collections can be infected

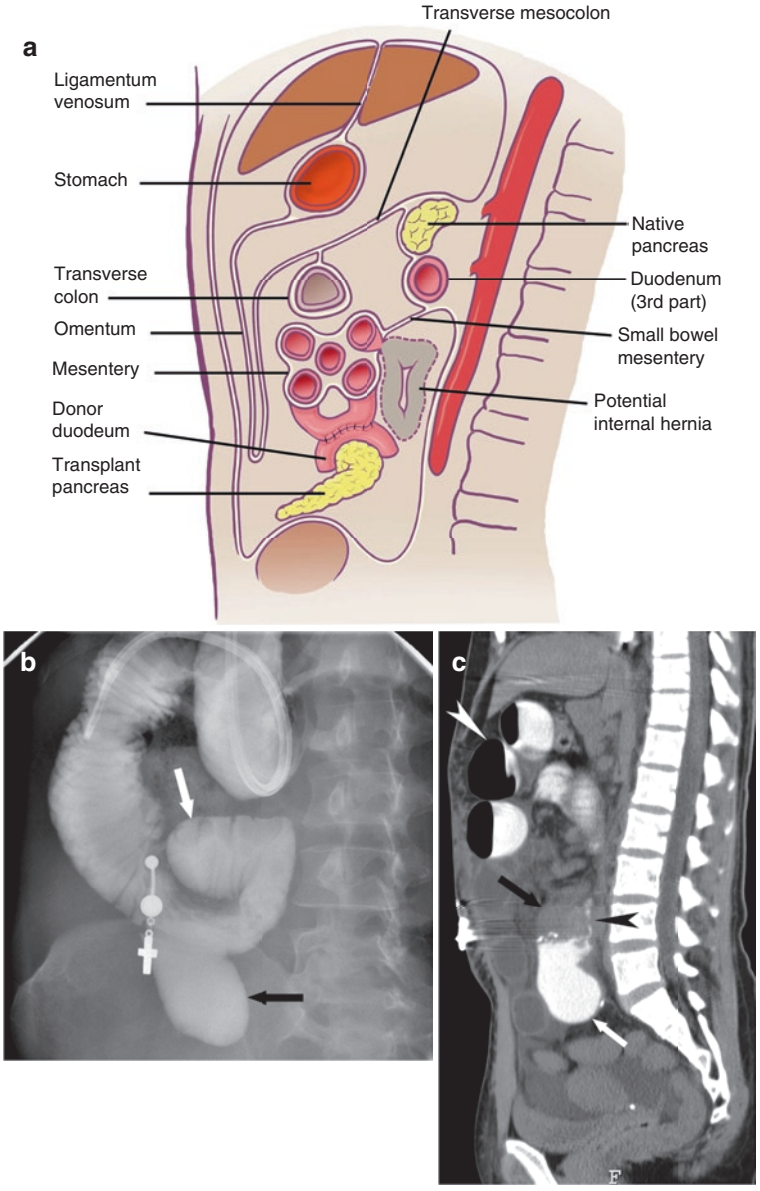

Fig. 6.15 (**a**) Sagittal illustration shows internal hernia following pancreas transplantation. Intraperitoneal placement of the transplant creates potential for internal hernia between donor duodenum/pancreatic allograft and posterior peritoneum. Hernia occurs through mesenteric defect used to attach donor duodenum to recipient jejunum. Used with permission from the Office of Visual Media, Indiana University. (**b**) This coronal fluoroscopic image from enteroclysis shows an internal hernia as a complication of pancreas transplant. Both the donor duodenum (black arrow) and loop of jejunum (white arrow) herniated through the mesenteric defect. (**c**) Sagittal CT image shows an internal following pancreas transplantation. Enteric contrast is filling the herniated jejunal loop (white arrow) through the neck of hernia (black arrowhead). Enteric contrast did not fill into the donor duodenum (black arrow). There is dilatation of the proximal small bowel loops (white arrowhead)

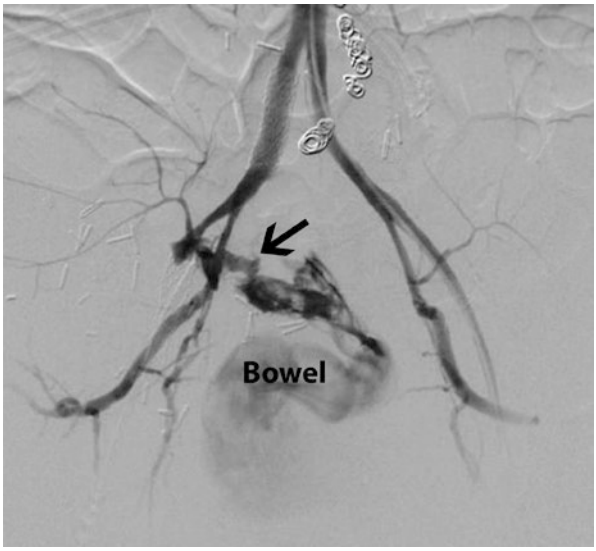

Fig. 6.16 Coronal conventional angiography image shows a fistula (arrow) between the graft artery and the bowel loop in the pelvis

and develop into an abscess or a pseudocyst. Postoperative hemorrhage is a potential complication that can be diagnosed by US, CT, or MRI. Fistula between the arterial graft and donor duodenum (Fig. 6.16) has been reported to be a source of major gastrointestinal bleeding that can be successfully treated with coil embolization [22].

References

1. Gruessner AC, Sutherland DE, Gruessner RW. Pancreas transplantation in the United States: a review. Curr Opin Organ Transplant. 2010;15(1):93–101. https://doi.org/10.1097/MOT.0b013e32833552d2.
2. Sutherland DE, Gruessner RW, Gruessner AC. Pancreas transplantation for treatment of diabetes mellitus. World J Surg. 2001;25(4):487–96. https://doi.org/10.1007/s002680020342.
3. Wullstein C, Woeste G, Zapletal C, Dette K, Bechstein WO. Simultaneous pancreas-kidney transplantation in patients with antiphospholipid syndrome. Transplantation. 2003;75(4):562–3. https://doi.org/10.1097/01.TP.0000046531.72372.48.
4. Smets YF, Westendorp RG, van der Pijl JW, de Charro FT, Ringers J, de Fijter JW, Lemkes HH. Effect of simultaneous pancreas-kidney transplantation on mortality of patients with type-1 diabetes mellitus and end-stage renal failure. Lancet. 1999;353(9168):1915–9. https://doi.org/10.1016/S0140-6736(98)07513-8.
5. Tyden G, Tollemar J, Bolinder J. Combined pancreas and kidney transplantation improves survival in patients with end-stage diabetic nephropathy. Clin Transplant. 2000;14(5):505–8.
6. Fernandez-Cruz L, Sabater L, Gilabert R, Ricart MJ, Saenz A, Astudillo E. Native and graft pancreatitis following combined pancreas-renal transplantation. Br J Surg. 1993;80(11):1429–32.
7. Guido W, Wolf OB. Handbook of renal and pancreatic transplantation. In: MacPhee IAM, Fronek J, editors. Chichester, West Sussex: Wiley-Blackwell; 2012. p. 194.

8. Boggi U, Amorese G, Marchetti P. Surgical techniques for pancreas transplantation. Curr Opin Organ Transplant. 2010;15(1):102–11. https://doi.org/10.1097/MOT.0b013e32833553de.
9. Freund MC, Steurer W, Gassner EM, Unsinn KM, Rieger M, Koenigsrainer A, Margreiter R, Jaschke WR. Spectrum of imaging findings after pancreas transplantation with enteric exocrine drainage: part 1, posttransplantation anatomy. AJR Am J Roentgenol. 2004;182(4):911–7. https://doi.org/10.2214/ajr.182.4.1820911.
10. Sollinger HW, Odorico JS, Knechtle SJ, D'Alessandro AM, Kalayoglu M, Pirsch JD. Experience with 500 simultaneous pancreas-kidney transplants. Ann Surg. 1998;228(3):284–96.
11. Gaber AO, Shokouh-Amiri H, Grewal HP, Britt LG. A technique for portal pancreatic transplantation with enteric drainage. Surg Gynecol Obstet. 1993;177(4):417–9.
12. Aideyan OA, Foshager MC, Benedetti E, Troppmann C, Gruessner RW. Correlation of the arterial resistive index in pancreas transplants of patients with transplant rejection. AJR Am J Roentgenol. 1997;168(6):1445–7. https://doi.org/10.2214/ajr.168.6.9168705.
13. Nelson NL, Largen PS, Stratta RJ, Taylor RJ, Grune MT, Hapke MR, Radio SJ. Pancreas allograft rejection: correlation of transduodenal core biopsy with Doppler resistive index. Radiology. 1996;200(1):91–4. https://doi.org/10.1148/radiology.200.1.8657950.
14. Liu Y, Akisik F, Tirkes T, Tann M, Sandrasegaran K, Jennings SG, Lin C, Kakarala B, Fridell JA, Powelson JA, Liang C. Value of magnetic resonance imaging in evaluating the pancreatic allograft transplant complications. Abdom Imaging. 2015;40(7):2384–90. https://doi.org/10.1007/s00261-015-0408-x.
15. Heverhagen JT, Wagner HJ, Ebel H, Levine AL, Klose KJ, Hellinger A. Pancreatic transplants: noninvasive evaluation with secretin-augmented MR pancreatography and MR perfusion measurements—preliminary results. Radiology. 2004;233(1):273–80. https://doi.org/10.1148/radiol.2331031188.
16. Hagspiel KD, Nandalur K, Pruett TL, Leung DA, Angle JF, Spinosa DJ, Matsumoto AH, Ahmed H, Sanfey HA, Sawyer RG, Burkholder B, Brayman KL. Evaluation of vascular complications of pancreas transplantation with high-spatial-resolution contrast-enhanced MR angiography. Radiology. 2007;242(2):590–9. https://doi.org/10.1148/radiol.2422041261.
17. Troppmann C. Complications after pancreas transplantation. Curr Opin Organ Transplant. 2010;15(1):112–8. https://doi.org/10.1097/MOT.0b013e3283355349.
18. Morgan TA, Smith-Bindman R, Harbell J, Kornak J, Stock PG, Feldstein VA. US findings in patients at risk for pancreas transplant failure. Radiology. 2016;280(1):281–9. https://doi.org/10.1148/radiol.2015150437.
19. Meador TL, Krebs TL, Cheong JJ, Daly B, Keay S, Bartlett S. Imaging features of posttransplantation lymphoproliferative disorder in pancreas transplant recipients. AJR Am J Roentgenol. 2000;174(1):121–4. https://doi.org/10.2214/ajr.174.1.1740121.
20. Lall CG, Sandrasegaran K, Maglinte DT, Fridell JA. Bowel complications seen on CT after pancreas transplantation with enteric drainage. AJR Am J Roentgenol. 2006;187(5):1288–95. https://doi.org/10.2214/AJR.05.1087.
21. Sandrasegaran K, Maglinte DD. Imaging of small bowel-related complications following major abdominal surgery. Eur J Radiol. 2005;53(3):374–86. https://doi.org/10.1016/j.ejrad.2004.12.017.
22. Lopez NM, Jeon H, Ranjan D, Johnston TD. Atypical etiology of massive gastrointestinal bleeding: arterio-enteric fistula following enteric drained pancreas transplant. Am Surg. 2004;70(6):529–32.