Basic Chapter

1

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1.1 Carcinoma of the Pancreatic Head/Periampullary Adenocarcinoma

1.1.1 Relevant Basic Information, Indication and Contraindication

Periampullary adenocarcinoma includes cancer of the pancreatic head, ampullary cancer, distal bile duct cancer, and duodenal cancer. About 70 % are carcinomas of the pancreatic head. The operation procedure is essentially the same for all of these types of neoplasms. The frequency of lymph node metastases in patients with pancreatic cancer is associated with a 5-year survival rate of only 5 % or less. This very aggressive tumor biology is the rationale for an extended lymph node resection in pancreatic cancer. Another major problem with performing operations for pancreatic head carcinoma is also the frequent presence of perineural invasion; perineural involvement is also associated with a very poor prognosis. Because involvement of the mesenteric neural plexus is extensive, it is difficult to achieve a negative, retroperitoneal margin even with a radical resection.

Clinical symptoms (usually jaundice related to obstruction of the distal bile duct), computed tomography (CT), and endoscopic retrograde cholangiopancreatography (ERCP) or magnetic resonance imaging (MRI)/magnetic resonance cholangiopancreatography (MRCP) lead to the diagnosis of a periampullary carcinoma. We prefer a high-quality, multiphase, contrast-enhanced, thin-section, helical CT including angio-CT (Table 1.1). MRI requires more time to perform, is more expensive, less available, and more difficult to read, yet MRI is less "invasive" compared to CT and ERCP; moreover, CT is usually easier for a surgeon to interpret than MR images. Preservation of fat around the major peripancreatic vascular structures suggests a lack of direct tumor invasion and is consistent with the clinical prediction of "resectability". Isolated involvement of the superior mesenteric vein or the portal vein is not necessarily a contraindication for resection. We believe that circumferential vessel involvement by tumor, infiltration of the hepatic or mesenteric artery, or occlusion by the tumor of these vessels should be absolute contraindications for resection. We use ERCP and biliary stents only selectively. If the diagnosis is clear and the operation can be done in a short time window, we see no need for insertion of an endoscopically placed endo-biliary stent when the findings on CT or MRI/MRCP are unclear, we will often proceed to ERCP including cytologic investigation. In the case of cholangitis or bilirubin levels >300 μmol/l (>18 mg/dl),

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Table 1.1 Diagnostic in patients with suspicion of a periampullary carcinoma

Diagnostic method	Questions
Clinic	Jaundice, pain, vomiting, weight loss, glucose intolerance, new diabetes, gastrointestinal bleeding, steatorrhea, palpable abdominal mass
Laboratory evaluation	Standard parameters
Standard chest X-ray	Pulmonary lesions, metastases
Ultrasound	Pancreatic tumor, ascites, liver metastases
CT (high quality multiphase contrast enhanced, thin-section helical CT), Angio-CT	Size and location of the tumor, relationship to the mesenteric and portal vein and hepatic and superior mesenteric artery, liver or lymph node metastases, peritoneal metastases
ERCP	Strictures and obstruction of pancreatic or bile duct, endobiliary stenting, biopsy – cytologic investigations
Endoscopic ultrasonography	Size and location of the tumor, relationship to the mesenteric and portal vein and hepatic and superior mesenteric artery, local lymph node metastases, strictures and obstruction of pancreatic or bile duct
MRT + MRCP + Angio-MRI	*All-in-one procedure, size and location of the tumor, relationship to the mesenteric and portal vein and hepatic and superior mesenteric artery, liver or lymph node metastases, peritoneal metastases, strictures and obstruction of pancreatic or bile duct*
Diagnostic laparoscopy (*in combination with the resection procedure – in one step*)	*Small liver metastases* (*which are not seen with CT or MRI*), *peritoneal metastases*
Preoperative biopsy	*Histological confirmation of the tumor, only important for nonresectable patients*

Italic = optional tests for specification of the diagnosis

endoscopic papillotomy and stenting is indicated. In practice, we often get patients with suspected pancreatic cancer referred from other hospitals or gastroenterology departments with biliary stenting already performed for the treatment of jaundice. In contrast to some authors, we have not seen a greater rate of postoperative complications (fistulas, infections, mortality) in patients with endobiliary stents placed preoperatively.

Endoscopic ultrasonography is a relatively non-invasive diagnostic tool to investigate the primary neoplasm. If the CT or MRI is unclear, the patient will get an endoscopic ultrasonography to confirm or supplement the other diagnostic results. We see no need for a preoperative biopsy in potentially resectable patients because of high rates of false-negative biopsies and the risk of tumor seeding. Pancreas biopsy is usually only necessary in patients who will not be resected and palliative therapy will be done.

Staging: Operative resection only benefits patients with loco-regional disease. Preoperative imaging/staging should be undertaken to exclude distant metastases. There should be no evidence of involvement of the hepatic, celiac, or superior mesenteric arteries and no diagnostic evidence of occlusion of the superior mesenteric or portal vein. Extensive resection should be avoided in patients with occlusion of the superior mesenteric vein (SMV) or portal vein (PV) and collateralization because of a strong risk of bleeding and a high mortality. Segmental vein resection and reconstruction of the portal and/or the superior mesenteric veins in selected patients provided a complete resection can be achieved with this procedure. Candidates for resection of the pancreatic head should have a good functional status and physiologic reserve to withstand the resection procedure. Chronologic age alone should not be a contraindication for pancreatic resection.

General contraindications for pancreas head resection are (exceptions are possible):

- Liver metastases
- Peritoneal metastases (malignant ascites)
- Other distant metastases
- Tumor involvement of the superior mesenteric artery (SMA) or hepatic artery
- Circumferential tumor involvement or occlusion of the SMV or PV
- Patient in an unsatisfactory medical condition, other relevant diseases limiting expected survival

Table 1.2 Steps of a standard procedure (Traverso–Longmire)

Resection	
1	Exploration
2	Biopsy of liver or peritoneal metastases if necessary
3	Elevation of the duodenum and pancreatic head (Kocher maneuver)
4	Division of the right half of the gastrocolic ligament
5	Mobilization of the right colon flexure
6	Division of the gastrohepatic ligament
7	Division of the gastroduodenal artery and identification of the portal vein on the superior border of the pancreas (attention of a relevant stenosis of the common hepatic artery or atypical arterial perfusion of the liver)
8	Exposure of the SMV at the inferior border of the pancreas
9	Division of the postpyloric duodenum
10	Freeing of the gallbladder and transection of the common hepatic bile duct
11	Division of the jejunum distal the ligament of Treitz and delivery the jejunum and the distal duodenum to the right of the superior mesenteric vessels
12	Division of the pancreas
13	Freeing the uncinate process and division of the lateral branches of the SMV and SMA
14	Complete lymphadenectomy
Reconstruction	
15	Pancreaticojejunostomy
16	Hepaticojejunostomy (optional t-tube)
17	Duodenojejunostomy
18	Drainage and closure of the abdominal wound

1.1.2 Surgical Technique

Our preferred procedure for pancreatic head resection is the pylorus-preserving pancreatoduodenectomy described by Longmire and Traverso (Table 1.2). Long-term survival has not been influenced by pyloric preservation in several studies. The Longmire/Traverso procedure is faster than the classic Kausch-Whipple procedure and perhaps more physiologic because of the preservation of the pylorus.

The pylorus-preserving pancreatoduodenectomy is started with a bilateral subcostal incision with an extension more to the right side of the upper abdomen (Fig. 1.1). We regularly use a self-retaining retraction system for the costal margin (Fig. 1.1). The liver and the peritoneal cavity are first inspected and palpated to exclude the presence of metastases. A wide Kocher maneuver is performed to confirm that the tumor does not invade the vena cava, the retroperitoneum, or the superior mesenteric artery (Fig. 1.2). Using bimanual palpation anterior and posterior to the SMA, it is possible to exclude a gross tumor involving the SMA. Direct tumor invasion of the ligament of Treitz is a strong indicator for involvement of the SMA and a contraindication for resection.

Next the right half of the gastrocolic ligament is divided between ligatures or with the harmonic scalpel. The greater omentum is preserved on the transverse colon. Usually, the vascular supply to the greater omentum remains excellent after this procedure. At the end of the operation, the greater omentum is placed in the subhepatic space in front of the pancreatic anastomosis to cover this area to "protect" the pancreaticojejunostomy. Overall, well-vascularized omentum helps to control postoperative complications of the pancreatic anastomosis; omentum with a poor blood supply should be resected. The right colon flexure is then mobilized from the liver, the duodenum, and the anterior surface of the pancreatic head. The transverse mesocolon is detached from the pancreatic head down to the right lateral aspect of the superior mesenteric vein (Fig. 1.3). For optimal exposure of the infrapancreatic superior mesenteric vein and the anterior surface of the pancreatic

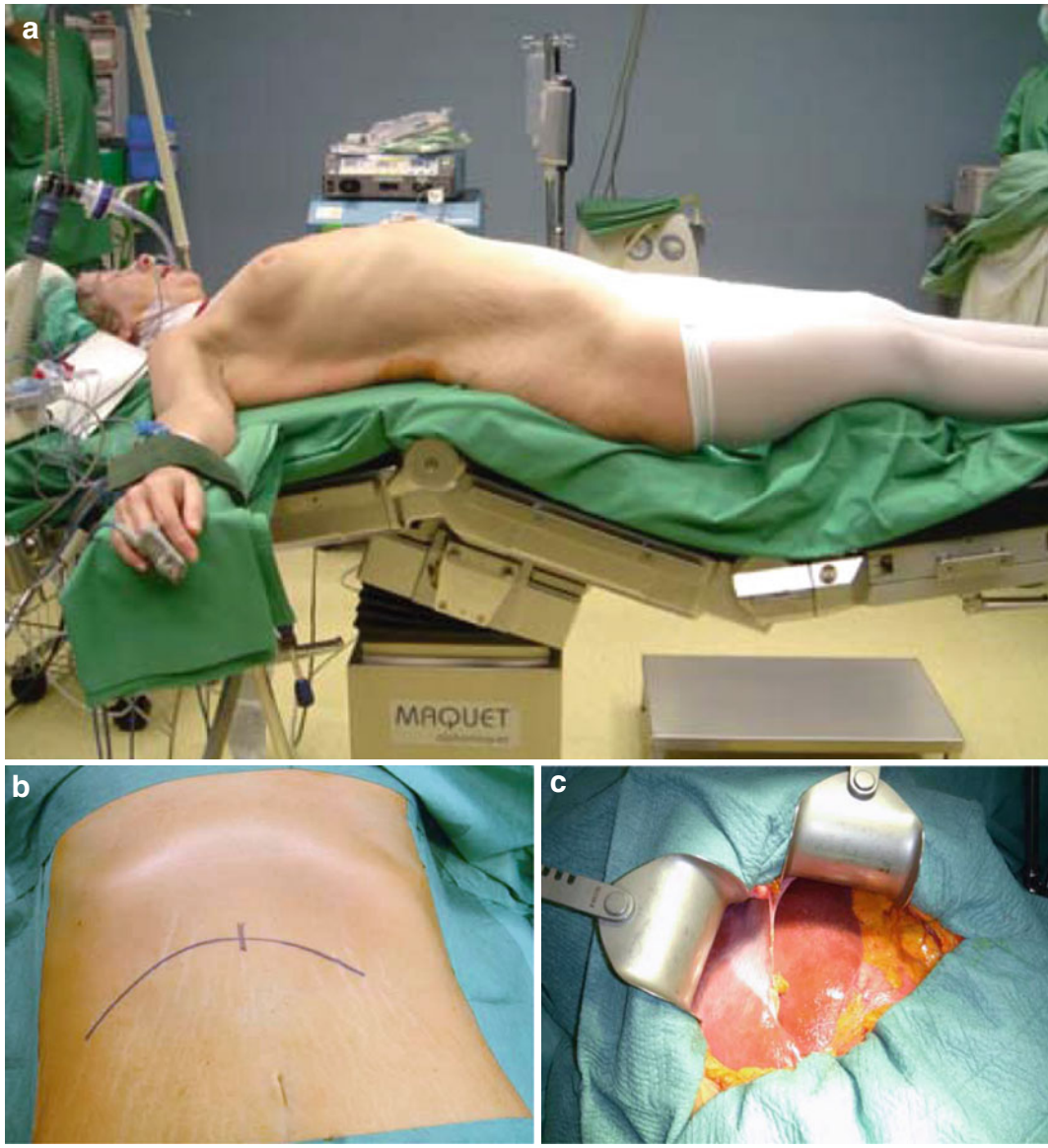
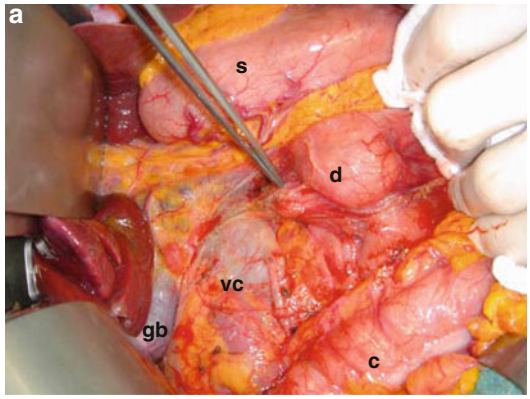
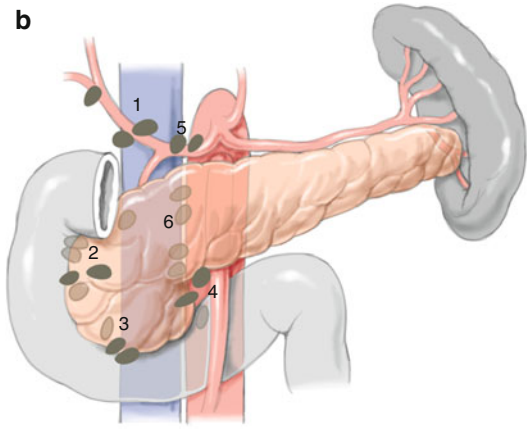


Fig. 1.1 Position of the patient (**a**), initiated incision for pylorus preserving pancreatoduodenectomy (**b**), and using a self-retaining retraction system after opening the abdomen (**c**)

head, it is necessary to divide the gastroepiploic artery and vein (gastrocolic trunk) (Fig. 1.3). The gastrohepatic ligament is then divided and the common hepatic artery, the gastroduodenal artery, and the suprapancreatic portal vein are identified (Fig. 1.4). Dividing the gastroduodenal artery is often necessary for a complete exposure and dissection of the suprapancreatic portal vein. The SMV is mobilized infrapancreatically by following the venous branches of the transverse mesocolon that drain into the SMV.

At this point, it is very important to confirm that the confluence of the superior mesenteric vein and the splenic vein with the portal vein is not invaded by tumor. Using a blunt clamp, the pancreatic tissue can be mobilized carefully from the anterior surface of the confluence of the veins (Fig. 1.5). If this mobilization is possible, this





1 gastroduodenal and hepatic ln
2 superior pancreaticduodenal anterior and posterior ln
3 inferior pancreaticduodenal anterior and posterior ln
4 mesenteric ln (right side of the SMA)
5 suprapancreatic ln (hepatic artery and right side of celiac trunk)
6 aortointercaval ln

Fig. 1.2 (**a**) Mobilization by Kocher (not yet completed). A retropancreatic lymph node is marked by forceps (*c* colon, *vc* vena cava inferior, *gb* gallblader, *s* stomach, *d* duodenum). (**b**) Relevant lymph node stations for carcinomas of the pancreatic head. *Gray* nodes are located behind the pancreas (*1* gastroduodenal and hepatic lymph nodes, *2* superior pancreaticoduodenal anterior and posterior lymph nodes, *3* inferior pancreaticoduodenal anterior and posterior lymph nodes, *4* mesenteric lymph nodes, *5* suprapancreatic lymph nodes, *6* aortointercaval lymph nodes) (From O´Morchoe 1997). (Illustration by Reinhold Henkel, Heidelberg)

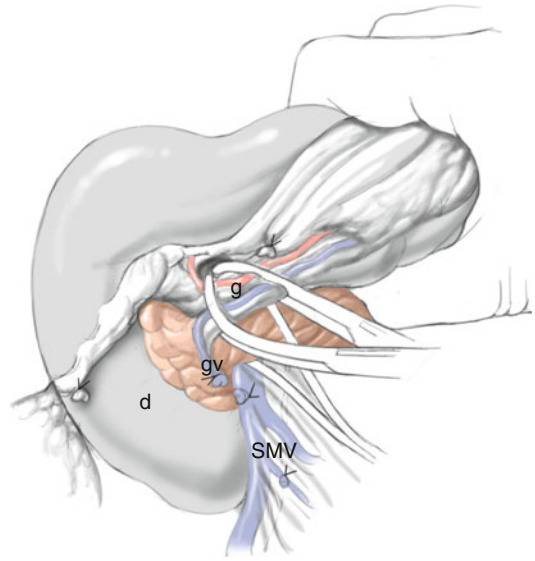
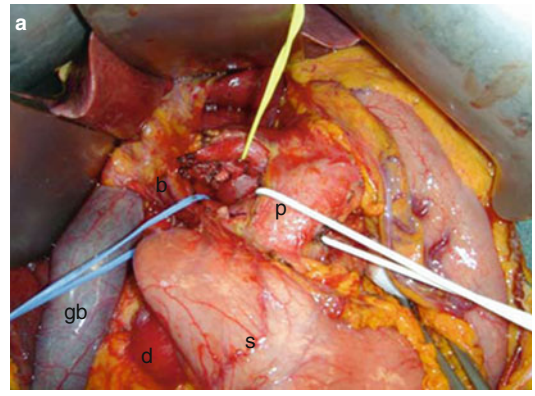


Fig. 1.3 The mesocolon transversum is detached from the pancreatic head to the right lateral aspect of the superior mesenteric vein and dividing the gastrocolic venous trunk (vena gastroepiploica dextra). The right gastroepiploic artery and vein are divided at the anterior surface of the pancreatic head (*g* right gastroepiploic artery and vein, *gv* divided gastrocolic venous trunk (vena gastroepiploica dextra), *SMV* superior mesenteric vein, *d* duodenum). (Illustration by Reinhold Henkel, Heidelberg)



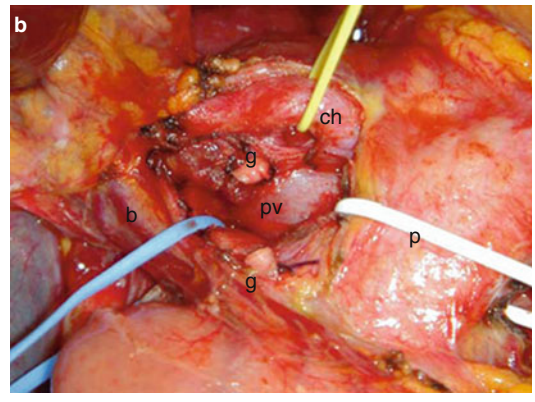


Fig. 1.4 (**a**, **b**) Identification of the common hepatic artery, the gastroduodenal artery and the suprapancreatic portal vein (*gb* gallbladder, *s* stomach, *d* duodenum, *p* pancreas over the venous confluence, *pv* portal vein suprapancreatic, *ch* common hepatic artery, *g* divided gastroduodenal artery, *b* bile duct)

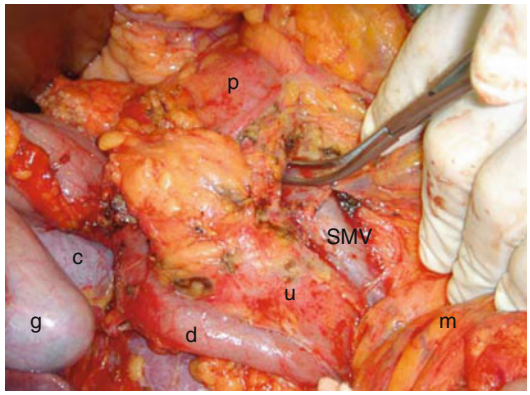


Fig. 1.5 Using a blunt clamp the pancreatic tissue can be carefully mobilized from the confluence of the superior mesenteric vein and the portal vein (*SMV* superior mesenteric vein, *p* pancreas, *d* duodenum, *u* uncinate process, *g* gallbladder, *m* mesocolon transversum, *c* vena cava inferior)

maneuver confirms resectability of the pancreatic head. In the absence of gross tumor infiltration of the duodenum, and especially in the postpyloric portion of the duodenum, a pylorus-preserving pancreatoduodenectomy is usually possible. The duodenum is then divided about 2–3 cm distal to the pylorus using a linear stapler (Proximate 75 mm Linear Cutter®, Ethicon Endo-Surgery, Johnson & Johnson, Somerville, USA, blue magazine). The stomach is then mobilized into the left upper abdomen. The gallbladder is removed and the common hepatic duct is transected superior to the junction with the cystic duct. To avoid continuous leakage of bile into the abdomen, the hepatic duct is occluded using a nontraumatic vascular clamp. The jejunum is divided about 8–12 cm distal to the ligament of Treitz using a linear stapler (Proximate 75 mm Linear Cutter® Ethicon Endo-Surgery, blue magazine) and the mesentery divided using the harmonic scalpel (Generator 300®Ethicon Endo-Surgery, Johnson & Johnson); the harmonic scalpel offers excellent control of bleeding and saves time. After mobilizing the ligament of Treitz and the fourth portion of the duodenum, there is free communication between the left and the right side of the abdomen posterior to the superior mesenteric vessels. The fourth portion of the duodenum and the short segment of devascularized proximal jejunum are then drawn to the right side of the abdomen posterior

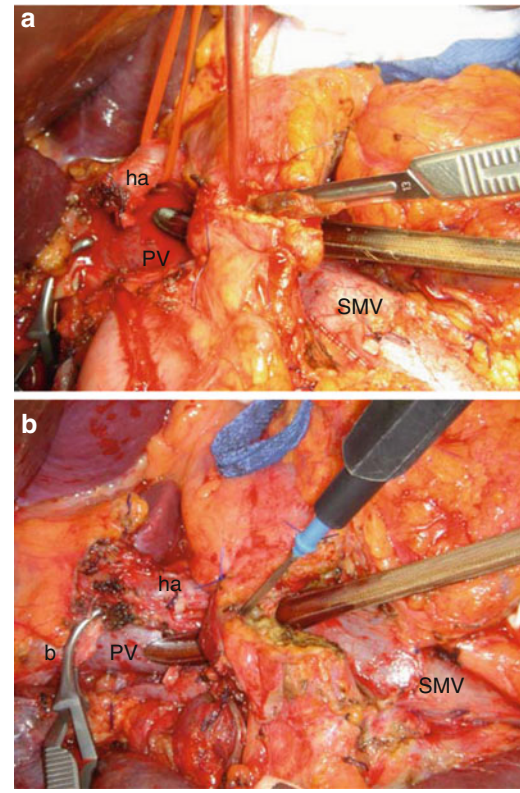


Fig. 1.6 (**a**, **b**) A special nonmetallic probe is placed in front of the venous confluence between the confluence and the pancreas and the pancreas is divided with a scalpel (using an electrocautery scalpel, cutting mode, low energy, a thermal necrotic zone on the specimen can complicate the diagnosis of a tumor free pancreatic margin by the pathologist) (*SMV* superior mesenteric vein, *b* bile duct, *PV* portal vein, *ha* hepatic artery)

to the superior mesenteric vessels through the bed of the duodenum. Before dividing the neck of the pancreas, we place single sutures on the superior and inferior rim of the pancreas (Prolene® 4/0, Ethicon) to control small vessels that often bleed during transection of the pancreas. A nonmetallic, special probe or a blunt clamp is placed anterior to the venous confluence but posterior to the neck of the pancreas, and the pancreas is divided with a regular scalpel (Fig. 1.6). When using an electrocautery instrument (cutting mode, low energy) to transect the pancreatic neck, the pathologist can encounter problems determining a tumor-free resection margin if the tumor has reached the thermal necrotic zone. Usually several bleeding points are evident after transection of the pan-

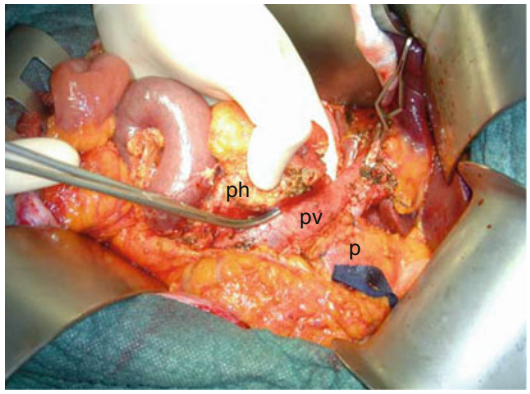


Fig. 1.7 The venous confluence will be exposed by a tension of the pancreas head with the left hand of the surgeon to the right. Small veins from the uncinate process to the superior mesenteric vein or in the portal vein were ligated selectively (*pv* portal vein, *p* pancreas corpus, *ph* pancreas head in the left hand)

creas. We use bipolar electrocautery for hemostasis of these bleeding points on both sides of the transected pancreatic tissue.

The venous confluence is now exposed. Rightward traction applied to the pancreatic head using the left hand is very helpful in this situation. Several small veins drain the uncinate process directly into the superior mesenteric vein or into the portal vein. Such branches are isolated and ligated selectively (Fig. 1.7). After this maneuver, the portal vein can be retracted medially. Sometimes, vascular involvement of the SMV or the portal vein is able to be seen only at the time of operation (a point of no return because the pancreas has been fully transected). Tumors in the uncinate process can be especially adherent to these vessels. Segmental vein resection and reconstruction of the portal and/or the superior mesenteric vein is possible if complete resection (RO) can be achieved with this procedure. Of course, those patients with vascular involvement also have a high rate of lymph node metastases and retropancreatic perineural infiltration. These facts limit the long-term survival independently of the RO vein resection. The long-term survival after RO resection including vein resection is, however, better than palliative surgery in several studies. Vein resection should be an individual decision in every patient.

Several types of vein resection are possible. The lateral wedge resection is the simplest procedure (Fig. 1.8). The vein is clamped using a "side-biting" vascular clamp laterally such that venous flow persists. The defect is closed over the vascular clamp with a continuous nonabsorbable 5/0 monofilament suture (Prolene®, Ethicon). The functional diameter of the SMV or portal vein should not be decreased significantly with this type of resection provided the lateral defect does not involve much of the circumference of the vein. For greater tumor involvement of the vein, a circumferential resection or venous patch reconstruction of the vein is a better oncologic procedure (Fig. 1.8). Venous reconstruction is possible with a primary anastomosis, an autologous vein graft (superficial femoral vein), or synthetic graft. We prefer to use an autologous vein graft, or a direct suture of the vein which ist often possible after a wide mobilization. The junction of the splenic vein and the SMV can be preserved by tangential excision of the SMV (Fig. 1.8). After dealing with the SMV and portal vein, attention is turned to resecting the uncinate process from the superior mesenteric artery. The superior mesenteric artery can and should be identified easily by palpation and visualization. The specimen is now only fixed by the retroperitoneal tissue around the SMA. Usually, many small lymphatic vessels are located in this tissue. This retroperitoneal margin of the specimen often shows invasion of tumor cells into the lymphatic vessels and perineural tissues which is the cause for the relatively high rate of local recurrence after resection of carcinomas in the pancreatic head. This tissue is divided on the right side of the SMA using individual ligatures or the harmonic scalpel. The inferior pancreaticoduodenal artery should be sought, isolated, and ligated selectively (Fig. 1.9). We send the complete specimen to the pathology department for frozen section analysis of the bile duct, pancreatic transection margin and, if necessary, the postpyloric duodenum. Positive resection margins need a further resection of the bile duct, pancreas, or stomach. Further resection in the area of the SMA (retroperitoneal margin) is usually not indicated or not possible, which is why we do not obtain a frozen section in this area.

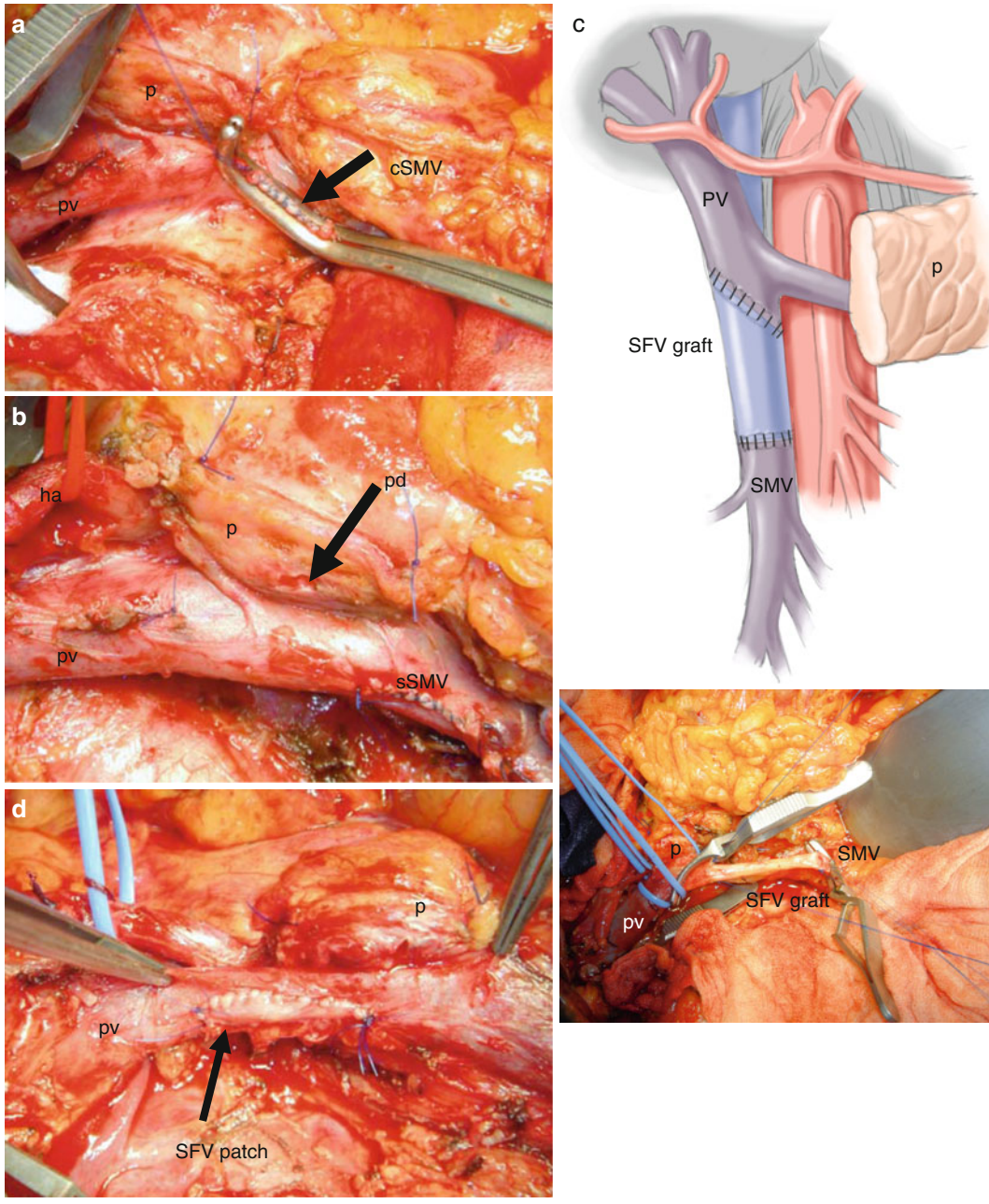


Fig. 1.8 (**a**–**d**) Portal vein reconstruction. The lateral wedge resection is the simplest procedure. The vein is clamped out laterally and the venous flow is still existent. The defect is closed over the vascular clamp with a continuous non absorbable 5/0 monofilament suture (Prolene®, Ethicon, Johnson and Johnson, Somerville, USA). The open diameter of the SMV or portal vein should not been reduced significantly (**a**, **b**). The drawing shows a tangential technique for interposition of a superficial femoral vein (*SFV*) segment with the intent to save the junction with the splenic vein (**c**). The reconstruction with a superficial femoral vein patch is also possible (**d**). (*cSMV* laterally clamped SMV, *p* pancreas, *pv* portal vein, *sSMV* sutured SMV, *ha* hepatic artery, *pd* pancreatic duct). (Illustration by Reinhold Henkel, Heidelberg)

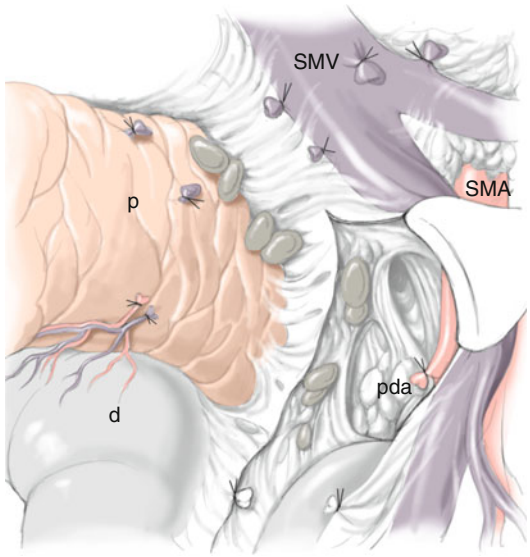


Fig. 1.9 Several small veins from the uncinate process or the pancreatic head which drain directly into the superior mesenteric vein or in the portal vein are ligated. The specimen is only fixed by the retroperitoneal tissue around the SMA. This tissue is divided on the right side of the SMA using sutures. The inferior pancreaticoduodenal artery should be isolated and ligated selectively (*SMV* superior mesenteric vein, *p* pancreas, *d* duodenum, *SMA* superior mesenteric artery, *pda* inferior pancreaticoduodenal artery). (Illustration by Reinhold Henkel, Heidelberg)

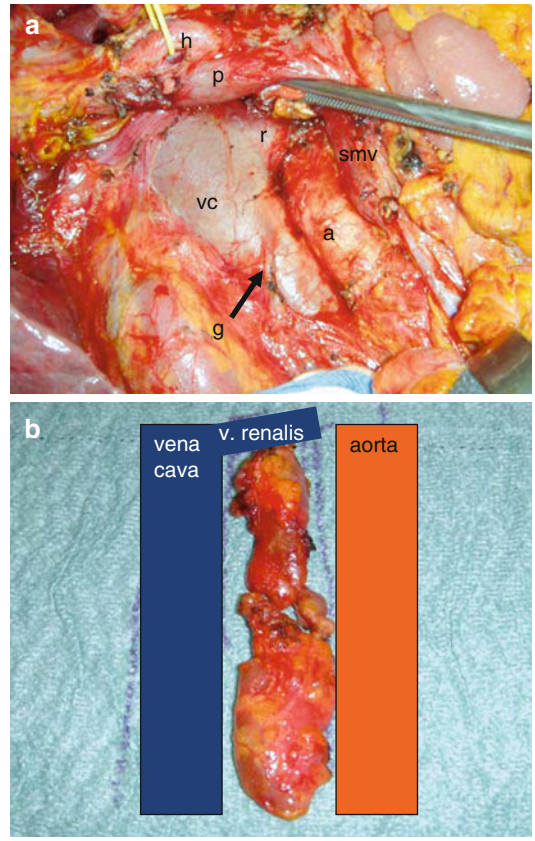


Fig. 1.10 Operation field after resection of the specimen at the retoperitoneal level of the anterior surface of the vena cava (**a**) and after dissection of the lymph nodes in the aortocaval sulcus (**b**) (*h* hepatic artery, *p* portal vein, *smv* superior mesenteric vein, *vc* vena cava, *a* aorta, *r* right renal vein, *g* gonadal vein)

Lymph node metastases are common in periampullary carcinoma and are critically relevant for prognosis. Extended lymphadenectomy is the standard procedure in our opinion. The extent of lymphadenectomy remains a matter of debate. During the pathologic investigation of the margins of the specimen, we complete the lymphadenectomy. The anterior and posterior pancreaticoduodenal lymph nodes are usually located in the specimen. For this reason, it is important to start the Kocher maneuver at the level of the right anterior wall of the inferior vena cava (Fig. 1.2). Usually, the right renal vein is identified at this time. Lymph nodes are removed from the hepatoduodenal ligament (caudal to the former cystic duct junction). Typically, lymph nodes from the cystic duct or from the corner between bile duct and duodenum are removed en bloc with the specimen. Other lymph nodes around the portal vein or hepatic artery are dissected separately (Fig. 1.2). We dissect the hepatic artery from its lymphatic tissue up to the level of the celiac trunk (level of the left gastric artery). We prefer to use bipolar cautery for this procedure. The lymph nodes on the right side of the SMA have been resected with the specimen. We avoid routine dissection of lymph nodes on the anterior and left side of the SMA because of the high morbidity (diarrhea, malnutrition). Other lymph nodes that appear to be malignant, besides the fourth portion of the duodenum and the ligament of Treitz, are also removed with the specimen. Lymph nodes in the aortocaval groove are removed separately (Fig. 1.10).

Reconstruction: The transected jejunum is pulled through a vascular window in the transverse mesocolon and into the subhepatic space. We prefer this pathway for the jejunal limb rather

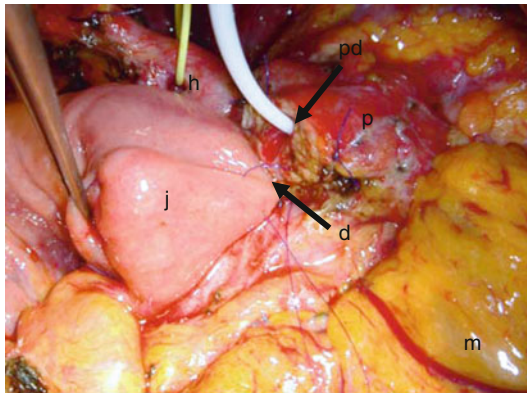


Fig. 1.11 Performing the outer posterior row using a low absorbable monofilament single sutures (PDS® 4/0 Ethicon, Johnson and Johnson, Somerville, USA), end-to-side anastomosis, pancreatic duct intubated with a flexible Simon–Weidner probe (*j* jejunal loop, *p* pancreas, *pd* pancreatic duct, *h* hepatic artery, *d* dorsal layer with single sutures, *m* transverse mesocolon)

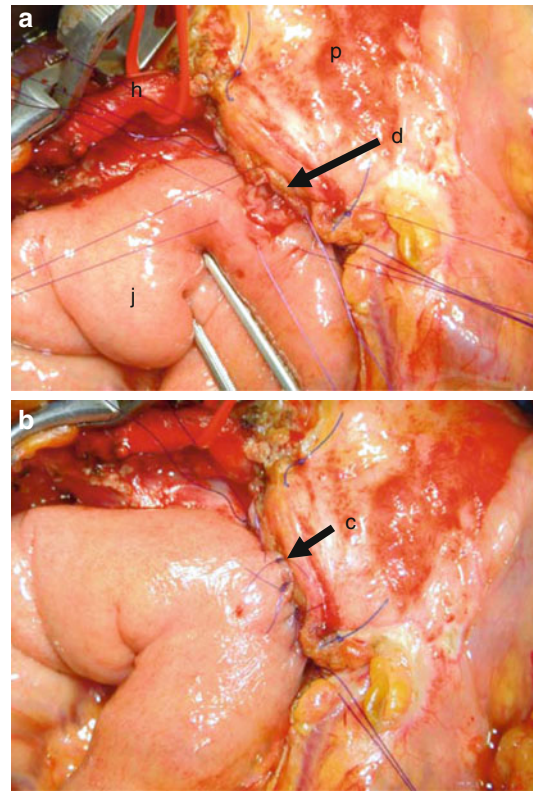


Fig. 1.12 (**a**, **b**) The pancreatic duct is fixed to a small incision in the corresponding jejunal limb using low-absorbable monofilament single sutures (PDS® 5/0, Ethicon, Johnson and Johnson, Somerville, USA). Depending on the size of the pancreatic duct we use 1 or 2 sutures on each side (posterior, anterior, cranial and caudal) (*j* jejunal loop, *p* pancreas, *h*- hepatic artery, *d* not sutured 5/0 PDS sutures – duct-to-mucosa anastomosis with five single interrupted sutures, *c* completed duct-to-mucosa anastomosis)

than posterior to the mesenteric vessels (in the bed of the duodenum) because of the risk of tumor recurrence in the area of the SMA and possible obstruction of the jejunal limb. The closed end of the jejunum is oversewn using a 4/O absorbable suture (Vicryl®, Ethicon). The jejunal limb placed subhepatic has no tension when positioned near the cut edge of the pancreatic remnant. The posterior surface of the pancreatic remnant is mobilized carefully from the venous confluence and the splenic vein using bipolar forceps cautery.

We perform a modified, Cattell-Warren, duct-to-mucosa anastomosis in an end-to-side fashion without stenting. We start with the outer, posterior row using absorbable, 4/0 monofilament interrupted sutures (PDS®, Ethicon) (Figs. 1.11 and 1.12). Depending on the size of the pancreatic duct, we use one or two sutures on each side (posterior, anterior, cranial, and caudal, minimum four sutures, maximum eight sutures). In some cases with a very small pancreatic duct, an anastomosis of the pancreatic duct to the jejunal mucosa with only two sutures still works. The outer anterior row between the pancreas and the jejunal wall is also done using an interrupted suturing technique using PDS® 4/0 (Ethicon) placed 3–5 mm between stitches (Fig. 1.13). The sutures between the pancreatic tissue and the jejunal limb are sometimes difficult to place

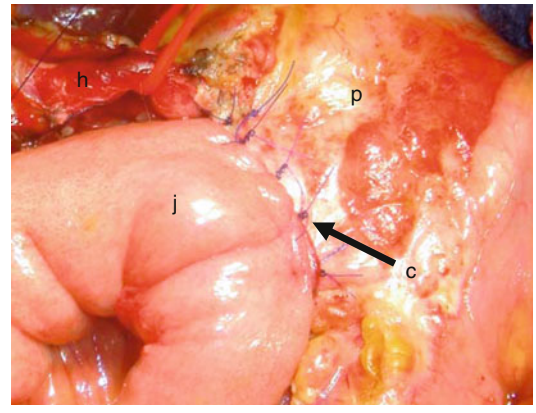


Fig. 1.13 Completed outer anterior row of the pancreaticojejunostomy, using PDS® 4/0 (Ethicon, Johnson and Johnson, Somerville, USA) in an interrupted single suture technique (*j* jejunal loop, *p* pancreas, *h* hepatic artery, *c* completed anterior row)

especially in nonchronic pancreatitis patients because of the softness of the pancreatic tissue. The amount of pancreatic tissue we include in the suture depends on the texture of the pancreas. In a very soft pancreas, the amount of needed pancreatic tissue is greater than in patients with a more fibrotic pancreas like in chronic pancreatitis. Sometimes, it is very helpful to use a U stitch technique to incorporate more tissue in the stitch. The technique of tying the knots itself is important, too. It is crucial to avoid any sawing movements with the suture. The suture should be tied very gently with mild compression of the two tissues with a distance of 3–5 mm between sutures.

Next, the end-to-side hepaticojejunostomy is performed 8–10 cm distal to the pancreatic anastomosis. This point is chosen to avoid kinking of the jejunal limb. The antimesenteric jejunum is opened using electrocautery. The jejunal enterotomy should be a little smaller than the lumen of the hepatic duct, because it will be dilated during manipulation. The posterior part of the anastomosis is performed with a single layer of continuous absorbable monofilament suture (PDS® 5/0, Ethicon) (Fig. 1.14), while the anterior part of the anastomosis is performed with a single layer of the same suture material. To allow better visualization, the sutures are not tied until all have been placed. When the lumen of the hepatic duct is very small, an anastomosis should be performed as described by Goetze-Guetgemann (Fig. 1.15). We do not routinely use t-tubes or stenting jejunal tubes. The jejunum is then fixed with two, single, absorbable sutures (Vicryl® 4/0, Ethicon) to the transverse mesocolon. The defect at the ligament of Treitz is obliterated to avoid hernias. Next, the attention is directed at restoring gastrointestinal continuity. We first inspect the postpyloric duodenum to assure sufficient vascular perfusion of the proximal duodenum. Sometimes the vascular inflow or outflow is compromised and the postpyloric area takes on a purplish, ischemic hue; because we know that is ischemia of the duodenal cuff results in impaired gastric emptying in the postoperative course, we prefer a distal resection of the stomach and reconstruction as described by Kausch-Whipple. If the blood perfusion to the postpyloric duodenum is sufficient, an antecolic, end-to-side duodenojejunostomy is performed in a double layer continuous technique with an absorbable suture (Vicryl® 4/0, Ethicon) (Figure 1.16).

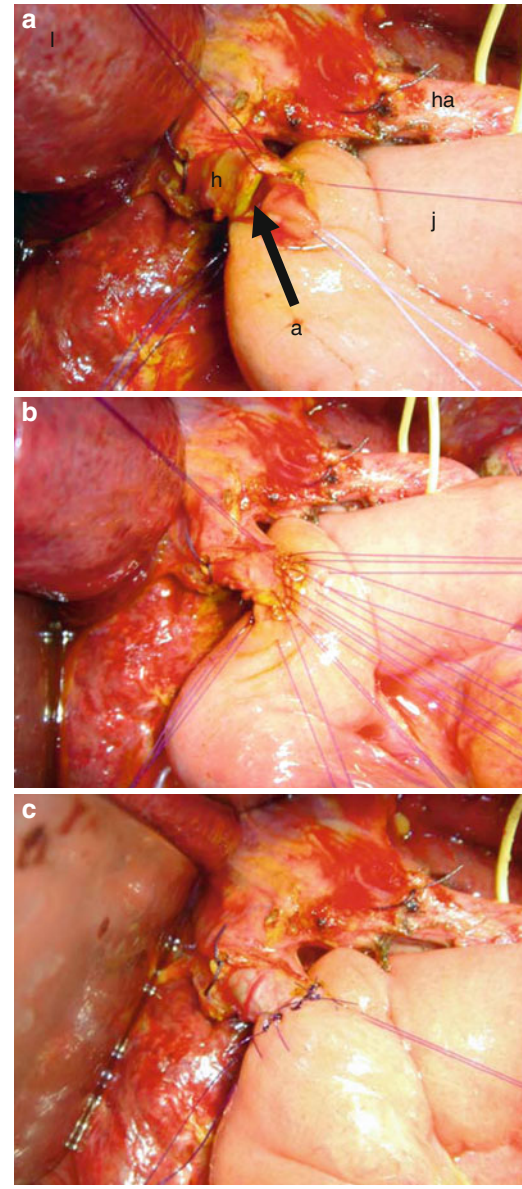


Fig. 1.14 A end-to-side hepaticojejunostomy is performed using a single-layer continuous absorbable monofilament suture (PDS® 5/0, Ethicon, Johnson and Johnson, Somerville, USA) in the back and a single layer interrupted absorbable monofilament suture (PDS® 5/0) in the front. (**a**) Continuous posterior row completed (*j* jejunal loop, *h* hepatic duct, *ha* hepatic artery, *l* liver, *a* anastomosis), (**b**) anterior row not yet sutured, (**c**) anastomosis completed

The biliary anastomosis and the posterior part of the pancreaticojejunostomy is drained by

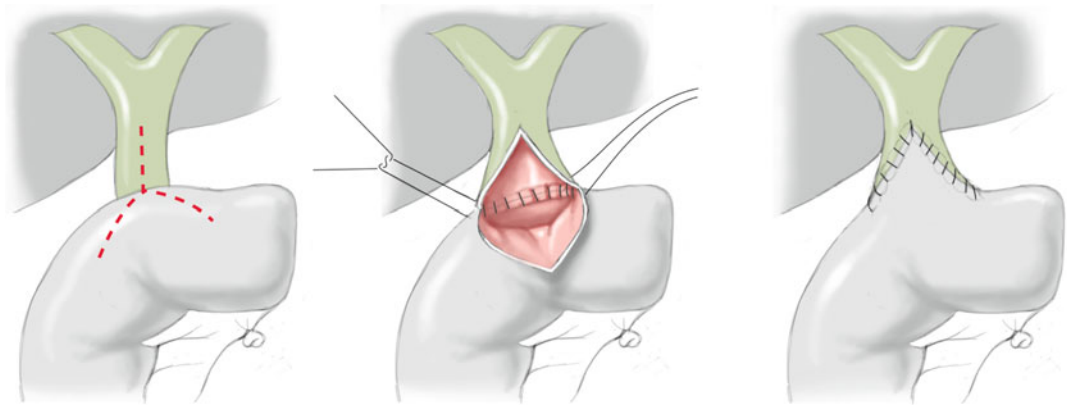


Fig. 1.15 In the case of a small lumen on the hepatic duct an anastomosis is performed as described by Goetze–Guetgemann to avoid stenosis. (Illustration by Reinhold Henkel, Heidelberg)

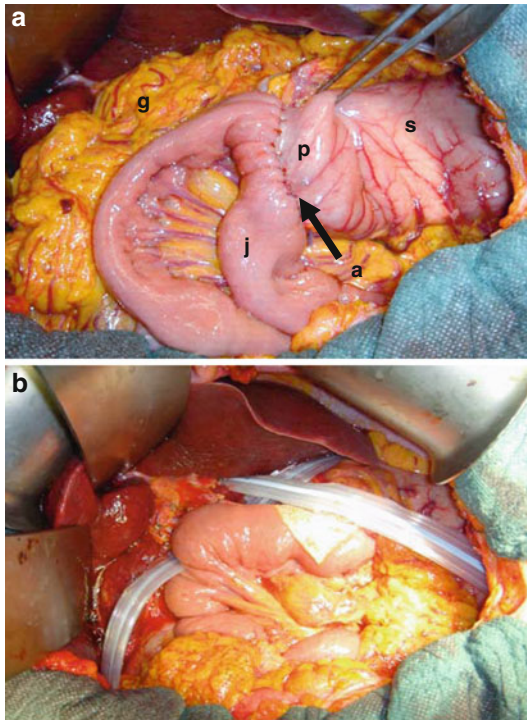


Fig. 1.16 (**a**, **b**) An antecolic end-to-side duodenojejunostomy is performed in a double layer continuous technique with a absorbable suture (Vicryl® 4/0, Ethicon, Johnson and Johnson, Somerville, USA). Multiple perforated easy flow drainage tubes are placed behind and in front of the pancreatic anastomosis. The pancreatic anastomosis is saved using a TachoSil® surgical patch (Nycomed Pharma, Unterschleissheim, Germany) (*s* stomach, *p* pylorus, *j* jejunal loop, *a* anastomosis, *g* the greater omentum is placed in front of the pancreatic anastomosis for a covering effect)

a 12 mm, multi-perforated, closed-suction drain (Easy Flow Drainage, P.J. Dahlhausen & Co. GmbH, Cologne, Germany) which is placed in the right subhepatic space and brought out through a stab wound in the right lateral abdomen. The anterior surface of the pancreatic anastomosis is also drained by a similar 12 mm drain which is placed anterior to the pancreaticojejunostomy and brought out through a stab wound in the left lateral abdomen (Fig. 1.16). The abdominal wound is closed in layers with two continuous layers of an absorbable, monofilament suture (PDS® 2, Ethicon).

1.1.3 Additional Medication and Procedures

- All patients undergoing an elective pancreatic operation are given perioperative antibiotic prophylaxis with a cephalosporin (Cefuroxin® 1.5 g, Fresenius KABI, Bad Homburg, Germany) and metronidazole (Metronidazol® 0.5 g, Fresenius KABI, Bad Homburg, Germany) 30 min preoperatively. The antibiotic is redosed if the operation lasts longer than 4 h. Only in patients with preoperative cholangitis is antibiotic therapy prolonged postoperatively.
- We use octreotide (100 µg subcutaneously; Sandostatin®, Novartis Pharma, Nuernberg,

Germany) for prophylaxis against the potential complications after pancreatic surgery beginning 2 h preoperatively and every 8 h postoperatively for 7 days.

- At the time of operation, we place a double lumen, gastric/jejunal tube (Nasojejunal Feeding tube with Gastric Drainage Tube® 18 FR, Novartis Pharma, Osthofen, Germany) with the end of the tube positioned 5–8 cm distal to the duodenojejunostomy. The distal lumen is used for enteral nutrition starting 4 h postoperatively and continuing at a rate of 10 ml/h until the 5th postoperative day when the tube is removed and oral intake is begun. Sips of water or tea are offered after the first postoperative day.
- All patients receive prophylaxis against deep vein thrombosis with low molecular weight heparin (0.3 ml Certoparin-Natrium, Mono-Embolex®, Novartis Pharma, Nuremberg, Germany) once daily, starting on the evening before operation and given until discharge.
- Prophylaxis against stress gastritis and anastomotic ulceration is given using a once daily dose of 40 mg pantoprazole intravenously (Pantozol®, Atlanta Pharma, Constance, Germany).
- If technically possible, all patients are treated with an epidural catheter for postoperative pain management.
- Postoperative ICU admission with invasive monitoring and laboratory analysis is routine.
- The perianastomotic intraperitoneal drains are removed when the volume of output is less than 50 ml/day (not before the fifth postoperative day). Drain output is not measured routinely for amylase. We only measure the amylase activity in the drain fluid when the output is high or the color is typical for a pancreatic fistula; in this situation, the drain is maintained in place until the amylase activity and the output volume are normalized. In the case of a persistent pancreatic fistula without clinically worrisome symptoms, the drain is removed gradually every day (2–3 cm/day). Usually any persistent fistula is drained into a dermal drain bag and will close by itself over time; for persistent drainage, we obtain an abdominal CT to exclude an undrained peripancreatic fluid collection. When clinical symptoms (fever, pain, leukocytosis) suggest a pancreatic fistula, abdominal CT will show an insufficiently drained, peripancreatic fluid collection; in this situation, the drains are maintained and usually require repositioning, placement of an additional pigtail catheter(s) or, rarely, reoperation. It may be necessary to stop oral nutrition and start octreotide therapy if the output is high. Antibiotics are often required as well, depending on the clinical symptoms and systemic response. Discharge with drains in situ is possible in these patients after clinical stabilization and resumption of oral nutrition.

1.1.4 Results

The results of this study are contained in Table 1.3.

1.2 Carcinoma of the Body and Tail of the Pancreas

1.2.1 Relevant Basic Information, Indications and Contraindications

About 30 % of pancreatic carcinomas are carcinomas of the body or tail of the pancreatic gland. These neoplasms often harbor a silent course because, in contrast to proximal pancreatic cancers which cause objective, obstructive symptoms of the bile duct or duodenum, cancers of the body/tail region do not lead to obstructive symptoms. Weight loss and pain are characteristic of this diagnosis but are often vague and insidious. CT, ERCP, and/or MRI/MRCP lead to the diagnosis of the carcinoma of the pancreatic body and tail. A pancreatic duct cut-off is the most common abnormality observed during ERCP. CT or MRI demonstrate the primary tumor in relation to the surrounding vascular structures or organs and can demonstrate liver metastases or lymph node metastases (Table 1.4). Endoscopic ultrasonography can offer additional information about local infiltration and involvement of surrounding structures as well as confirming or supplementing the findings on CT or MRI/MRCP. Besides ductal adenocarcinoma of the body and tail of the pancreas, endocrine,

Table 1.3 Patients with periampullary carcinoma and resection (2006, 2007)

Parameter	Number	%
Patients	68	100
Hospital mortality	2	2.9
Hospital stay (median, days)	24 (8–84)	
Relaparotomy	5	7
Death without local complications	0	0
Whipple procedure	11	16
Longmire-Traverso procedure	57	84
Tumor stage (UICC)		
Ia	1	1.5
Ib	6	8.8
IIa	18	26.5
IIb	40	58.8
III	2	2.9
IV	1	1.5
R0 resection rate	50	73.5
R1 resection rate	15	22
R2 resection rate	3	4.5
Postoperative local morbidity		
Postoperative bleeding[a]	2	2.9
Delayed gastric emptying[b]	3	4.4
Pancreatic fistula[c]	15	22
Biliary fistula[d]	1	1.5
Wound infection	14	20.6
Other (i.e. abscess, pleural effusion)	21	30.9
Postoperative systemic morbidity		
Systemic complications[e]	6	8.8

[a]Need for relaparotomy
[b]Nasogastric intubation ≥10 days, need for reinsertion of a nasogastric tube because of vomiting, or the inability to tolerate a solid diet after the 14th postoperative day. Other definitions: Inability to eat after 10 postoperative days; intolerance to oral intake and need for nasogastric decompression after the seventh postoperative day
[c]Drain output of any measurable volume of fluid on or after postoperative day 3 with an amylase activity greater than 3 times the serum amylase activity. Other definitions: Persistent drainage of more than 30 ml amylase-rich fluid (>5,000 units) per day for more than 10 days; drainage of more than 30 ml of amylase-rich fluid (at least 3 times the upper normal limit of serum amylase activity) per 24 h after the 5th postoperative day
[d]Bilirubin-rich fluid was drained for more than 5 days
[e]Cardiopulmonary, renal, sepsis, neural, other

neuroendocrine neoplasms, the spectrum of cystic pancreatic neoplasms, and other less common neoplasms (metastases, sarcomas, etc.) can be located in this area. Involvement of the more distal splenic vein or artery is usually no problem for resection, but tumor involvement of the celiac trunk, the superior mesenteric artery, or the superior mesenteric vein almost always indicates unresectability. Partial resection of the superior mesenteric vein or portal vein with a patch repair using tissue from the superficial femoral vein is possible in selected cases if R0 resection seems otherwise possible. Long-term survival after extended resections is described in the literature. Overall, however, the prognosis is influenced strongly by the nodal status. Statistically, node-positive patients may not benefit from such extended resections; however, only resection provides a chance of cure. Distant metastases (liver or peritoneum) are contraindications to resection. In patients noted to be unresectable preoperatively, tissue diagnosis by percutaneous fine needle aspiration biopsy is indicated. Only about 10 % of all pancreatic adenocarcinomas of the body or tail can be resected. In the case of unclear preoperative diagnostic staging, exploration is indicated to confirm unresectability.

1.2.2 Surgical Technique

Distal pancreatectomy with splenectomy is the standard technique for cancer of the pancreatic body and tail (Table 1.5). We prefer an antegrade approach because this technique provides excellent visualization of the operating field and allows easy control of the splenic artery and vein early in the phase of the procedure.

Antegrade distal pancreatectomy with splenectomy is begun with a bilateral, subcostal incision with extension more to the left side of the abdomen. We regularly use a self-retaining retraction system for the costal margin in all pancreatic resections (Fig. 1.1). The liver and the peritoneal cavity are first inspected and palpated to exclude metastases. The lesser omentum is opened for the initial exploration of the lesser sac. After dividing the gastrocolic ligament, the view into the lesser sac is now wide open allowing access to the anterior surface of the entire body and tail of the gland. Using this operating plan, it is necessary to save the right gastroepiploic artery for the blood supply of the

Table 1.4 Diagnostic in patients with suspicion of a carcinoma of the body or pancreatic tail

Diagnostic method	Questions
Clinic	Pain, weight loss, palpable abdominal mass
Laboratory	Evaluation Standard parameters
Standard chest X-ray	Pulmonary lesions, metastases
Ultrasound	Pancreatic tumor, ascites, liver metastases
CT (high quality multiphase contrast-enhanced, thin-section helical CT), Angio-CT	Size and location of the tumor, relationship to the mesenteric and portal vein and hepatic and superior mesenteric artery, liver or lymph node metastases, peritoneal metastases
ERCP	Strictures and obstruction of pancreatic duct
Endoscopic ultrasonography	Size and location of the tumor, relationship to the mesenteric and portal vein and celiac trunk, local lymph node metastases
MRT + MRCP + Angio-MRI	*All in one procedure, Size and location of the tumor, relationship to the mesenteric and portal vein and hepatic and superior mesenteric artery, liver or lymph node metastases, peritoneal metastases, strictures and obstruction of pancreatic or bide duct*
Diagnostic laparoscopy (in combination with the resection procedure – in one step)	*Small liver metastases (which not seen with CT or MRI), peritoneal metastases*
Preoperative biopsy	*Histological confirmation of the tumor, only important for nonresectable patients*

Italic = optional tests for specification of the diagnosis

Table 1.5 Steps of a standard procedure (distal pancreatic resection for cancer)

Resection	
1	Exploration
2	Biopsy of liver or peritoneal metastases if necessary
3	Division of the of the gastrocolic ligament (save the right gastroepiploic artery for the blood supply of the greater omentum if you use this technique)
4	Freed any lienocolic and gastrocolic attachments and divide the short gastric vessels (mobilization of the left colon flexure)
5	The common hepatic artery, the celiac trunk and the origin of the splenic artery are visualized to confirm respectability
6	Identification of the portal vein on the superior border of the pancreas
7	Exposure of the SMV at the inferior border of the pancreas
8	Mobilize carefully the confluence of the superior mesenteric vein, the portal vein and the splenic vein from caudal
9	The splenic artery is divided at the origin o the celiac trunk
10	Division of the pancreas using a stapler, separate ligature of the splenic vein
11	Mobilize the pancreas from medial and caudal to the retroperitoneum in a antegrade way. After passing the SMA go posterior. The anterior surface of the left adrenal gland, the adrenal vein and left renal vein marked the posterior plan of dissection
12	Frozen section of the pancreatic margin on the specimen
13	Complete Lymphadenectomy
14	Drainage and closure of the abdominal wound

greater omentum. An alternative approach involves gaining access to the lesser sac by dissecting the greater omentum off the transverse colon and retracting the omentum rostrally. Any lienocolic and gastrocolic attachments in the left upper abdomen are transected between clamps or with the harmonic scalpel. Use of the harmonic scalpel saves time in this situation and the short gastric vessels can be divided with the harmonic scalpel as well (gastrosplenic ligament).

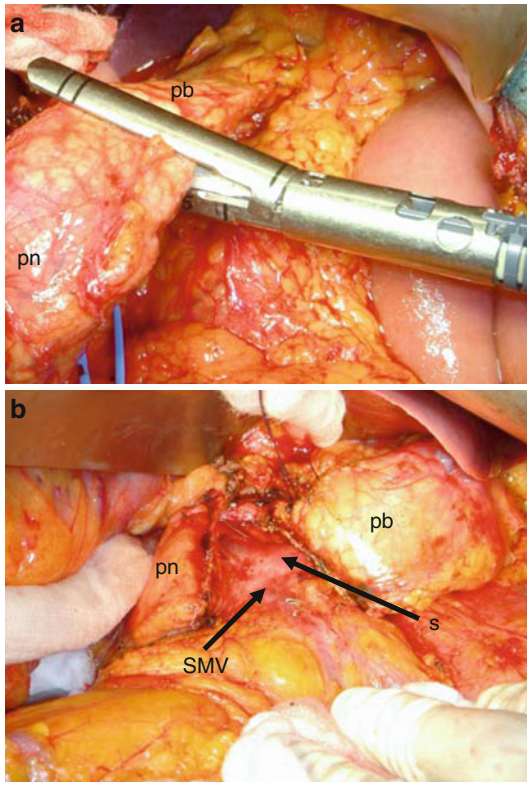


Fig. 1.17 (**a**, **b**) The neck of the pancreas is divided using a stapler (ETS Flex® 45 mm, white magazine, Ethicon, Johnson and Johnson, Somerville, USA). After dividing the pancreatic neck the venous confluence is clearly seen (*pn* pancreatic neck, *pb* pancreatic body, *SMV* superior mesenteric vein, *s* splenic vein)

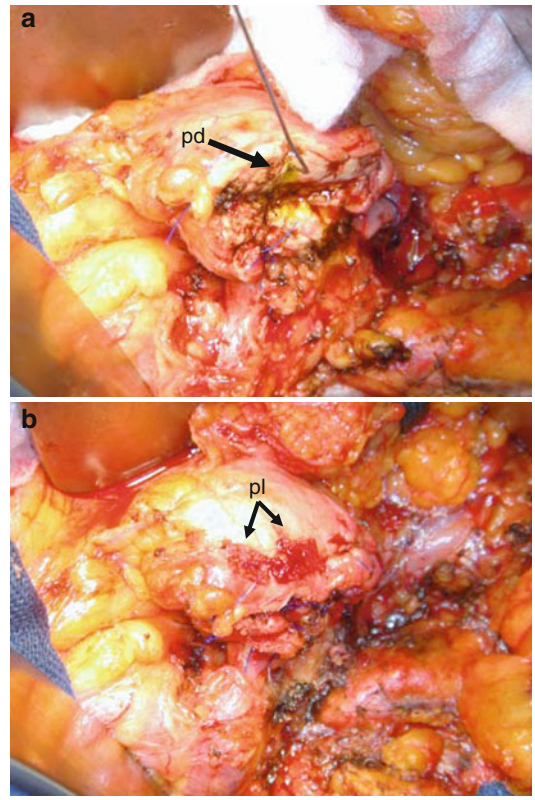


Fig. 1.18 (**a**) A larger pancreas can be closed using a fish mouth incision with selectively ligation of the pancreatic duct. (**b**) To avoid sawing, the use of absorbable undyed pledgets is possible (Ethisorb®, pledget undyed, absorbable, Ethicon, Johnson and Johnson, Somerville, USA) (*pd* with metal probe marked pancreatic duct, *pl* pledgets)

The common hepatic artery, the celiac trunk, and the origin of the splenic artery are visualized and isolated to confirm resectability in this area. Lymph nodes in this area are dissected using bipolar forceps. The suprapancreatic portal vein is exposed by retracting the gastroduodenal artery. Likewise, the SMV is mobilized infrapancreatically. At this point is very important to confirm that the confluence of the superior mesenteric vein and the portal vein is not invaded by tumor. Using a blunt clamp, the pancreatic tissue can be mobilized carefully from the anterior surface of the confluence of the superior mesenteric vein and the splenic vein to the portal vein. If this mobilization is possible and the celiac artery, SMA, and common hepatic artery are uninvolved, resectability is confirmed.

The splenic artery is first divided at the origin of the celiac trunk. The neck of the pancreas is divided using a stapler (Ethicon, Johnson & Johnson, Somerville, USA, ETS Flex® 45 mm, white magazine) (Fig. 1.17). The proximal pancreatic stump is sealed using a small TachoSil® patch (Nycomed Pharma, Unterschleissheim, Germany) (Fig. 1.18). There is usually no need for additional sutures to reinforce the closure of the pancreatic duct. When using this stapling procedure, it is important that the pancreatic duct in the head has no stenosis and a free outflow of the pancreatic secretion into the duodenum is exists (MRCP or ERCP confirmation preoperatively is preferred). Intubation or ductography of the pancreatic duct is not possible after stapling dissection of the pancreas. A narrowing of the pancreatic duct will usually lead to a pancreatic

fistula. In the case of stenosis of the remnant proximal pancreatic duct, a Roux-en-Y pancreaticojejunostomy should be performed to prevent a pancreatic stump fistula.

After dividing the pancreatic neck, the venous confluence is seen clearly (Fig. 1.17). The splenic vein is divided between ligatures at the confluence with the SMV, avoiding leaving a redundant segment of splenic vein that would thrombose and potentially propagate into the portal vein to cause portal vein/SMV thrombosis postoperatively. When the neck of the pancreas is thick (>1.5–2 cm), transection/occlusion with a stapler is not reliable; in this situation, we transect the pancreas with a fishmouth-type incision and specifically and selectively ligate the pancreatic duct in the stump (Fig. 1.18). Sutures are also placed to close the anterior and posterior aspects of the pancreatic stump over the ductal closure; to avoid these sutures cutting or sawing through the usually soft, normal pancreatic parenchyma, the use of absorbable pledgets is possible (Ethisorb®, pledget undyed, absorbable, Ethicon, Johnson & Johnson, Somerville, USA).

The posterior surface of the body of the pancreas is next mobilized anteriorly from the retroperitoneum. This plane of dissection is at first anterior to the SMA. Fat and fibrous tissue is divided using bipolar forceps. The plan of dissection then goes posteriorly on the left side of the SMA down to the aorta. The lymph nodes anterior and on the left side of the aorta are taken in this step. The operative plan now shifts to the left side, and the pancreas is mobilized from the retroperitoneum. The anterior surface of the left adrenal gland, the adrenal vein, and the left renal vein mark the posterior plane of dissection (Fig. 1.19). During this maneuver, the inferior mesenteric vein is ligated. Using this technique, the superior part of Gerota's fascia of the kidney is taken with the specimen (Fig 1.19). This dissection is more aggressive than the classic technique of "retrograde" distal pancreatectomy. Our belief is that carcinoma of the body or tail has the same tumor biology as pancreatic head carcinoma. The frequency of retroperitoneal infiltration or lymph node metastases is high, unfortunately,

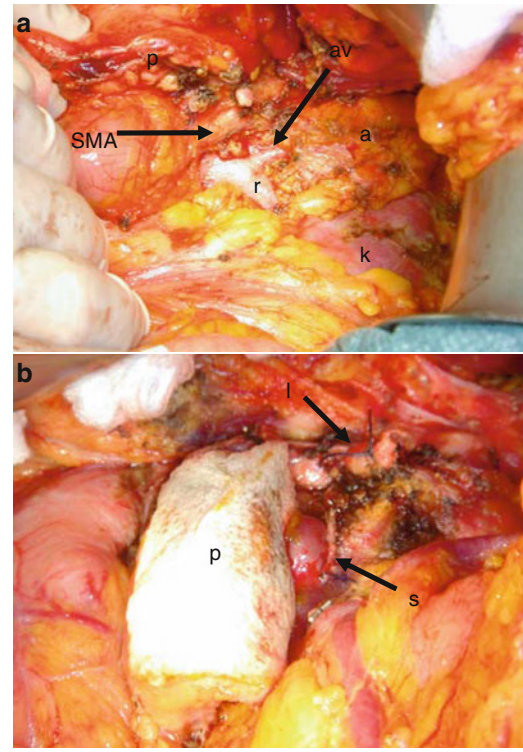


Fig. 1.19 (**a**) The anterior surface of the left adrenal gland, the adrenal vein and left renal vein marked the posterior plan of dissection. The upper part of the Gerota's fascia of the kidney is taken with the specimen. (**b**) The pancreatic stump is additionally saved using a small TachoSil® surgical patch (Nycomed Pharma, Unterschleissheim, Germany) (*k* left kidney, *r* renal vein, *a* adrenal gland, *av* adrenal vein, *SMA* superior mesenteric artery, *p* pancreatic stump, *s* sutured splenic vein, *l* ligated splenic artery)

in both types of carcinoma. Therefore, we have also adopted the use of an aggressive approach of resection in pancreatic body or tail carcinomas which involves resection of retroperitoneal, retropancreatic tissue including several lymphatic vessels and including several lymph node stations (Fig. 1.20). Involvement of the colon, stomach, or adrenal gland needs resection of these structures en bloc with the pancreatic tumor. Special attention is given to the posterior resection margin (adrenal gland, kidney) and the resection margin in the area of the pancreatic neck over the SMV/PV. After dividing the lienorenal ligament, the specimen is completely mobilized. The left lateral aspect of the resection is sometimes

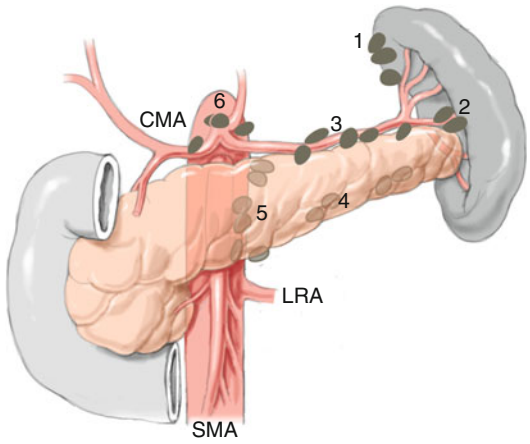


Fig. 1.20 Relevant lymph node stations for carcinomas of the body or tail of the pancreas. Gray drawn nodes are located behind the pancreas (*1* gastrosplenic lymph nodes, *2* splenic lymph nodes, *3* suprapancreatic lymph nodes, *4* infrapancreatic lymph nodes, *5* mesenteric lymph nodes, *6* celiac lymph nodes, *CHA* common hepatic artery, *LRA* left renal artery, *SMA* superior mesenteric artery) (Modified from O´Morchoe (1997)). (Illustration by Reinhold Henkel, Heidelberg)

difficult. In these cases, the spleen is lifted anteriorly to allow the distal part of the pancreas to be dissected.

The pancreatic margin on the specimen is investigated by frozen section to confirm a tumor-free margin. A 12 mm multiply perforated, closed suction drain (Easy Flow Drainage 12 mm®, P. J. Dahlhausen & Co. GmbH) is placed near the pancreatic stump and brought out through a stab wound in the left lateral abdomen. The pancreatic stump is then covered with the greater omentum, which is placed into the lesser sac superior to the transverse colon and posterior to the stomach. The abdominal wound is closed in two layers with continuous absorbable monofilament suture (PDS® 2, Ethicon).

1.2.3 Additional Medication and Procedures

- All patients undergoing an elective pancreatic operation are given perioperative antibiotic prophylaxis with a cephalosporin (Cefuroxin® 1.5 g, Fresenius KABI, Bad Homburg, Germany) and metronidazole (Metronidazol® 0.5 g, Fresenius KABI, Bad Homburg, Germany) 30 min preoperatively. The antibiotic is redosed if the operation lasts longer than 4 h. Only in patients with preoperative cholangitis is antibiotic therapy prolonged postoperatively.
- We use octreotide (100 μg subcutaneously; Sandostatin®, Novartis Pharma, Nuremberg, Germany) for prophylaxis against the potential complications after pancreatic surgery beginning 2 h preoperatively and 8 h postoperatively for 7 days.
- All patients are given sips of tea or water on the first postoperative day. Oral nutrition is started with yogurt and liquid nutrition on the third postoperative day.
- Prophylaxis against stress gastritis and anastomotic ulceration is given using a once daily dose of 40 mg pantoprazole intravenously (Pantozol®, Atlanta Pharma, Constance, Germany).
- If technically possible, all patients are treated with an epidural catheter for postoperative pain management.
- Postoperative ICU admission with invasive monitoring and laboratory analysis is routine.
- The perianastomotic intraperitoneal drains are removed when the volume of output is less than 50 ml/day (not before the fifth postoperative day). Drain output is not measured routinely for amylase. We only measure the amylase activity in the drain fluid when the output is high or the color is typical for a pancreatic fistula; in this situation, the drain is maintained in place until the amylase activity and the output volume are normalized. In the case of a persistent pancreatic fistula without clinically worrisome symptoms, the drain is removed gradually every day (2–3 cm/day). Usually any persistent fistula is drained into a dermal drain bag and will close by itself over time; for persistent drainage, we obtain an abdominal CT to exclude an undrained

Table 1.6 Patients with a carcinoma of the body or tail of the pancreas (2006, 2007)

Parameter	Number	%
Patients	20	100
Hospital mortality	1	5
Hospital stay (median, days)	20 (9–34)	–
Relaparotomy	1	5
Death without local complications	0	0
Tumor stage (UICC)		
Ia	0	0
Ib	3	15
IIa	5	25
IIb	12	60
III	0	0
IV	0	0
R0 resection rate	17	85
R1 resection rate	1	5
R2 resection rate	2	10
Postoperative local morbidity		
Postoperative bleeding[a]	2	10
Pancreatic fistula[b]	3	15
Wound infection	1	5
Other (i.e. abscess, pleural effusion)	8	40
Postoperative systemic morbidity		
Systemic complications[c]	1	5

[a]Need for relaparotomy
[b]Drain output of any measurable volume on or after three postoperative days with an amylase activity greater than three times the serum amylase activity. Other definitions: Persistent drainage of more than 30 ml of amylase-rich fluid (>5,000 units) per day for more than 10 days; drainage of more than 30 ml of amylase-rich fluid (at least three times the upper normal limit of serum amylase activity) per 24 h after the fifth postoperative day
[c]Cardiopulmonary, renal, sepsis, neural, other

peripancreatic fluid collection. When clinical symptoms (fever, pain, leukocytosis) suggest a pancreatic fistula, abdominal CT will show an insufficiently drained, peripancreatic fluid collection; in this situation, the drains are maintained and usually require repositioning, placement of an additional pigtail catheter(s) or, rarely, reoperation. It may be necessary to stop oral nutrition and start octreotide therapy if the output is high. Antibiotics are often required as well, depending on the clinical symptoms and systemic response. Discharge with drains in situ is possible in these patients after clinical stabilization and resumption of oral nutrition.

1.2.4 Results

The results of this study are contained in Table 1.6.

Reference

O'Morchoe CCC (1997) Lymphatic system of the pancreas. Microsc Res Tech 37:456–477