2 Percutaneous Biliary Procedures

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2.1 Introduction

Percutaneous biliary interventions (PBI) are common procedures performed in the management of various pathologies involving the biliary system. They mostly include percutaneous transhepatic biliary drainage (PTBD), biliary stenting (BS), and percutaneous cholecystostomy. An interventional radiology (IR) specialist plays a pivotal role in performing these procedures and has become an integral part of the multidisciplinary team managing patients with biliary diseases. In view of increasing incidence of various biliary diseases, e.g., gallbladder cancer, post-surgical biliary complications, the need for these procedures has increased tremendously. Hence, a thorough knowledge of these biliary procedures is necessary for optimal patient management. This chapter describes the indications, contraindications, basic steps, and complications of various biliary interventions.

2.2 Hardware

A complete familiarity with the required hardware is necessary for performing any successful intervention. The hardware necessary for PBI is shown in Figs. 2.1 and 2.2. The list is not exclusive and the IR specialist may choose any other hardware which he or she feels appropriate for the procedure.

The puncture needle chosen, usually 17G or 18G, should allow passage of a 0.035 inch guidewire. Its length should be appropriate (7–15 cm), as a too long needle will be difficult to control and a too short needle may not reach the target. This should be assessed prior to the procedure. For non-dilated or mildly dilated system, 21G or 22G needle with 0.018 guidewire is used.

The soft, teflon coated, hydrophilic guidewire (0.035 or 0.032 inch, 145 cm long) is used to obtain access after the initial puncture and for crossing the strictures. The extrastiff or ultrastiff guidewire (0.035 inch, 145 cm long) is used during dilatation of the tract or stricture, placement of catheters, and deployment of stents. Longer length of stiff wire (260 cm) may be necessary when stents are deployed, especially ones with long shaft length (135 cm). Dilators required depend on the final size of the catheter placed, usually range from 6F to 12F. A 8F catheter is usually sufficient to drain the bile in most situations. Only when there is too much debris or sludge in the biliary system, a large bore catheter (10F or 12F) is necessary for drainage. The caliber of the metallic biliary stents used is usually 8 mm or 10 mm, usually self-expandable uncovered stents. The length varies, depending on the length of the stricture. Cytology brush and biopsy

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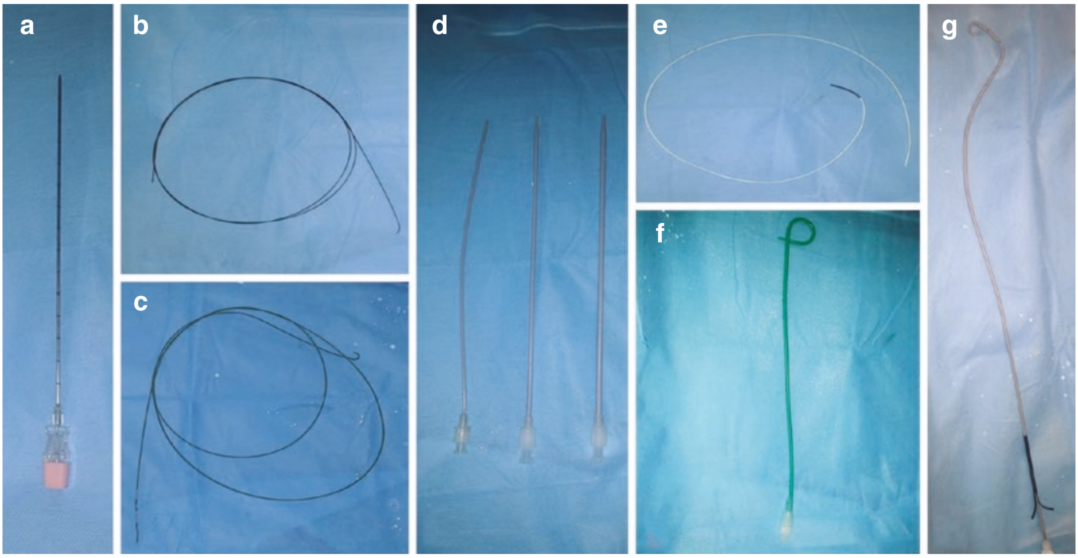

Fig. 2.1 Hardware used for PTBD. (**a**) 18G, 15 cm long two-part puncture needle. (**b**) Soft hydrophilic J-tip 0.035 inch guidewire. (**c**) Extrastiff 0.035 inch guidewire. (**d**) Serial dilators. (**e**) Short length angled 5F catheter for biliary manipulation. (**f**) 8F pigtail catheter for external drainage. (**g**) 8.3F ring biliary catheter for internal–external drainage

forceps are used when the diagnosis of malignant or indeterminate strictures has failed by standard techniques.

2.3 Methods of Drainage

There are three methods of drainage (Fig. 2.3) [1]. First is *external* drainage, wherein a pigtail/malecots catheter is placed proximal to the obstruction, to allow the bile to drain to an externally connected bag (Fig. 2.3a). This, however, cannot be a permanent solution as there is a loss of fluid and bile salts which cause dehydration and electrolyte imbalance. Thus, internal drainage should always be attempted. But in some situations like where the stricture could not be crossed or there is cholangitis, external drainage catheter is placed. Combined, i.e., *internal–external* drainage is placed in such a way that there are holes in the catheter proximal and distal to the stricture (Fig. 2.3b). This allows the bile to flow into the duodenum resulting in normal anatomical drainage. The external portion of the catheter may be connected to a bag for external drainage. Internal drainage is done after internalization and resolution of cholangitis. This catheter has the advantage of better stability, reduced loss of fluids, and the option of allowing internal drainage whenever necessary after capping the external end and an option of external draibage if internal drainage is not optimal. The third type is total *internal* drainage when the bile is drained only internally (Fig. 2.3c). This is possible by either capping the external end of the internal–external drainage catheter or by placing a biliary stent.

2.4 Percutaneous Transhepatic Biliary Drainage (PTBD) for Malignant Biliary Obstruction

PTBD, as the name indicates, is a percutaneous interventional procedure performed for the drainage of the bile, externally, internally, or both, through a catheter positioned in the biliary tract. Malignancies causing biliary obstruction, like gallbladder cancer or cholangiocarcinoma, result in the dilatation of intrahepatic bile ducts (IHBD).

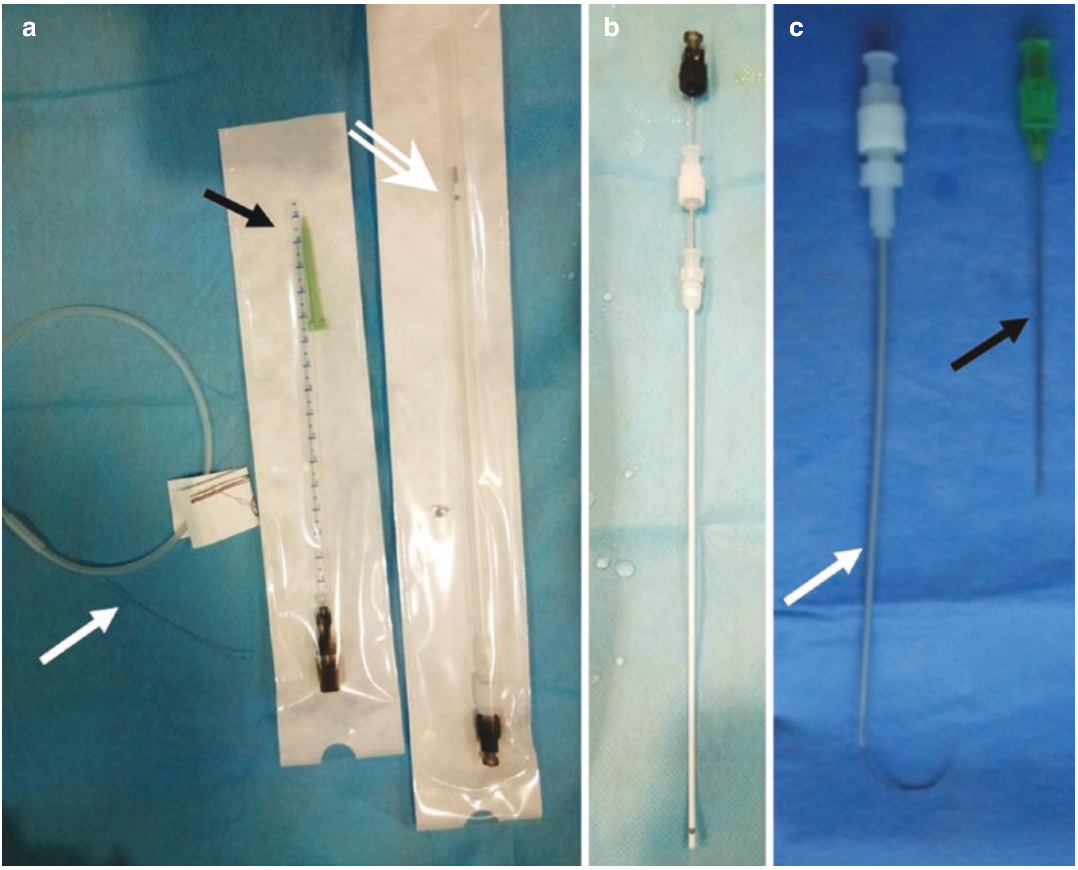

Fig. 2.2 Hardware for non-dilated biliary system. (**a**) Set of accessories including 22G, 15 cm puncture needle (black arrow), 0.018 inch guidewire (white arrow), and three-part introducer set (open arrow). (**b**) Introducer set with central stiffening canula, and coaxial 4F and 6F sheaths. (**c**) Another set with 21G, 7 cm needle (black arrow), and 5F coaxial dilator with 0.018 inch guidewire (white arrow)

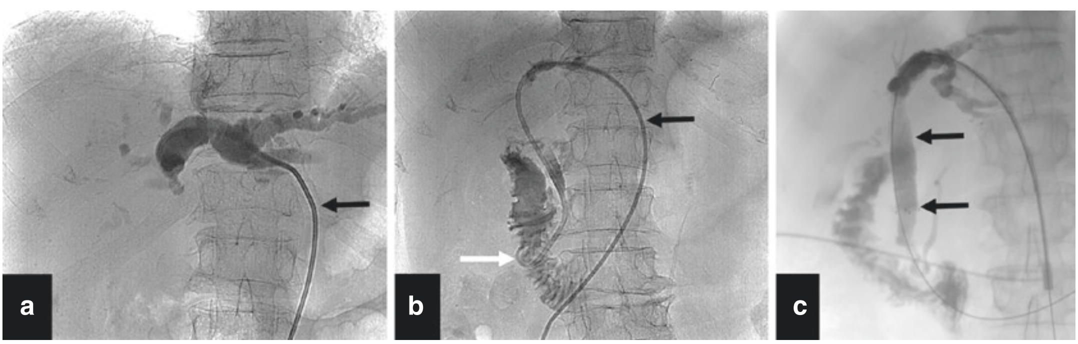

Fig. 2.3 Methods of biliary drainage. (**a**) External drainage where pigtail catheter (arrow) drains bile externally. (**b**) Combined external–internal drainage, where ring biliary catheter (black arrow) drains bile externally as well as internally through its tip in the duodenum (white arrow). (**c**) Internal drainage where a stent (arrows) drains the bile into the duodenum, allowing physiological drainage

The obstruction causes jaundice, pruritus, liver dysfunction, and cholangitis, due to stasis of bile [2, 3]. The purpose of PTBD is to relieve patient's symptoms (jaundice, pruritus), prepare the patient for chemotherapy or surgery (usually serum bilirubin <5 mg/dL) [4] and to drain infected bile (in cholangitis).

2.4.1 Indications

The most common indication for PTBD in malignant obstruction is cholestsasis with tumor-causing hepatic hilar obstruction, i.e., involving primary biliary confluence (high biliary obstruction). The advantage of PTBD is this situation is that one can choose which duct to drain and that when a stent is placed, the ampullary sphincter function is not disturbed [1]. Other indications include mid or low biliary obstruction where endoscopic biliary drainage (EBD) is either not possible due to patient's comorbid conditions or failed due to difficult anatomy or cannulation or in cases of altered anatomy (Roux-en-Y hepaticojejunostomy, Billroth II surgery, gastric bypass). PTBD is also indicated in patients presenting with acute cholangitis due to obstruction at any level, as the patient is often not fit for an EBD. Further, this is also the route for performing some biliary procedures like brush biopsy, radiofrequency ablation (RFA), and photodynamic therapy (PDT) [2, 5].

2.4.2 Contraindications

There is no absolute contraindication for performing a PTBD.

Relative contraindications include—deranged coagulation parameters, ascites, presence of skin site infection, large abscesses or tumors precluding a safe access route, lobar atrophy (unless it is infected), and uncontrolled hypertension. In patients with coagulopathy, which is not uncommon in these patients due to associated liver dysfunction caused by biliary obstruction, PTBD is done after its correction [6]. This can be done with fresh frozen plasma, if the indication for PTBD is urgent (e.g., cholangitis) or with correction after administering Vitamin K injection for few days, in nonurgent cases. Ascites increases the risk of bleeding during the procedure and makes the procedure technically difficult as the liver frequently gets pushed during the insertion of dilators or catheter. Also, there are higher chances of pericatheter leak of ascitic fluid. Hence, it should be drained as much as possible prior to PTBD. In patients with mild ascites, often there is no fluid anterior to the left lobe when the patient is in supine position, and a left PTBD is possible.

2.4.3 Clinical Presentation

Patients with malignant biliary obstruction usually present with painless progressive jaundice of short duration (usually few months). There may be associated loss of weight and appetite. Sometimes, high-grade fever with chills may be the initial presentation due to cholangitis. Laboratory investigations reveal elevated serum bilirubin (direct component), usually above 5–10 mg/dL. Alkaline phosphatase is also raised in these patients.

2.4.4 Pre-Procedure Imaging

As with any radiological intervention, prior imaging is necessary to plan a PTBD [2, 3]. Optimal imaging in these cases is typically a contrast enhanced computed tomography (CECT) scan (preferably multiphase as it helps in staging of the disease as well) or magnetic resonance imaging (MRI) with magnetic resonance cholangiopancreatography (MRCP). This gives information about the cause and level of obstruction. The level of obstruction determines whether a PTBD (high/hilar obstruction) or EBD (mid or low obstruction) should be done. The local staging of the disease helps determine the possible surgical procedure (hepatectomy or extended hepatectomy) and accordingly a right or left PTBD is decided. Similarly, the longitudinal extent of biliary involvement (i.e., involvement of secondary biliary confluence) also determines the side to be drained (uninvolved side to be drained) and the need of multiple drains. It is important to drain the remnant liver and not the part of the liver which will be removed at surgery. The volume of the lobes or segments of the liver can also be evaluated, which again determines the lobe or segment to be drained. Ascites, when present, should be drained as described above.

2.4.5 Patient Preparation

Once it is decided that the patient needs PTBD, urgent or elective, the patient is to be prepared for the procedure. The patient should be admitted, in elective cases, at least 6 h prior to the procedure. A minimum of 4 h of fasting is necessary. Any derangement in the coagulation parameters should be corrected. Ascites, if present, should be drained. The international normalized ratio should be <1.5 and platelet count should be more than 50,000/mL [7]. The part (epigastrium to right later lower chest wall) should be prepared.

The patient should be given a dose of broad-spectrum antibiotic (penicillins or cephalosporins), 12 h prior to the procedure and continued for 2–5 days after the procedure [8]. We usually inject 1 g ceftriaxone intravenously. Adequate hydration is needed and intravenous fluids should be infused. The blood pressure (BP) should be measured. If high, a dose of antihypertensive medication should be given to bring the BP to normal.

2.4.6 Procedure of PTBD

Once the patient is prepared, he should be shifted to the fluoroscopy table in the interventional suite for the procedure. The patient is positioned supine and connected to the pulse monitor to check the vital parameters. Initial screening ultrasonography (USG) is done to check for dilatation of IHBD, level of obstruction, volume of the liver lobes/segments, status of primary and secondary biliary confluence, and ascites.

2.4.6.1 Selection of Site/Side

Depending on the findings on the initial imaging and USG at the time of the procedure, the site of PTBD is decided (Fig. 2.4). When the primary confluence is patent, either left or right-sided PTBD can be performed. When the primary confluence is blocked, the side should be chosen based on the type of surgery planned, involvement of secondary confluence, and the volume of the lobe drained.

2.4.6.2 Right PTBD or Left PTBD

Drainage of only 25–30% of liver parenchyma is sufficient to improve serum bilirubin level and improve liver function. Hence, in cases of hilar obstruction, drainage of one lobe is adequate. The left PTBD is more comfortable for the patient and there are fewer chances of pleural complications, but is associated with higher radiation dose and difficult manipulation [6]. In such situations, either right or left PTBD may be chosen. Our experience has suggested that there is no difference between right and left PTBD in terms of technical difficulty, radiation dose (to operator and patient), patient comfort, and complications [9]. However, since the most common cause of malignant biliary obstruction with hilar involvement is carcinoma of the gallbladder, a left PTBD is preferred as the left lobe of the liver is the remnant liver.

2.4.6.3 Preparation of the Part

Once the side of PTBD is decided, the area around the puncture site, beginning from the level of mid chest to the level of umbilicus, is cleaned with povidone-iodine and chlorhexidine solution. The area is draped with a long drape extending down to cover the lower limbs completely. This is helpful to maintain sterility of the long wires used during the procedure.

2.4.6.4 Anesthesia/Analgesia

The procedure is done under light to moderate sedation, using fentanyl, midazolam, propofol, and ketamine intravenously. Occasionally, patients may need general anesthesia. The site of puncture is anesthetized using 2% lignocaine, about 10 mL. It is injected along the puncture tract, from the liver capsule to the skin.

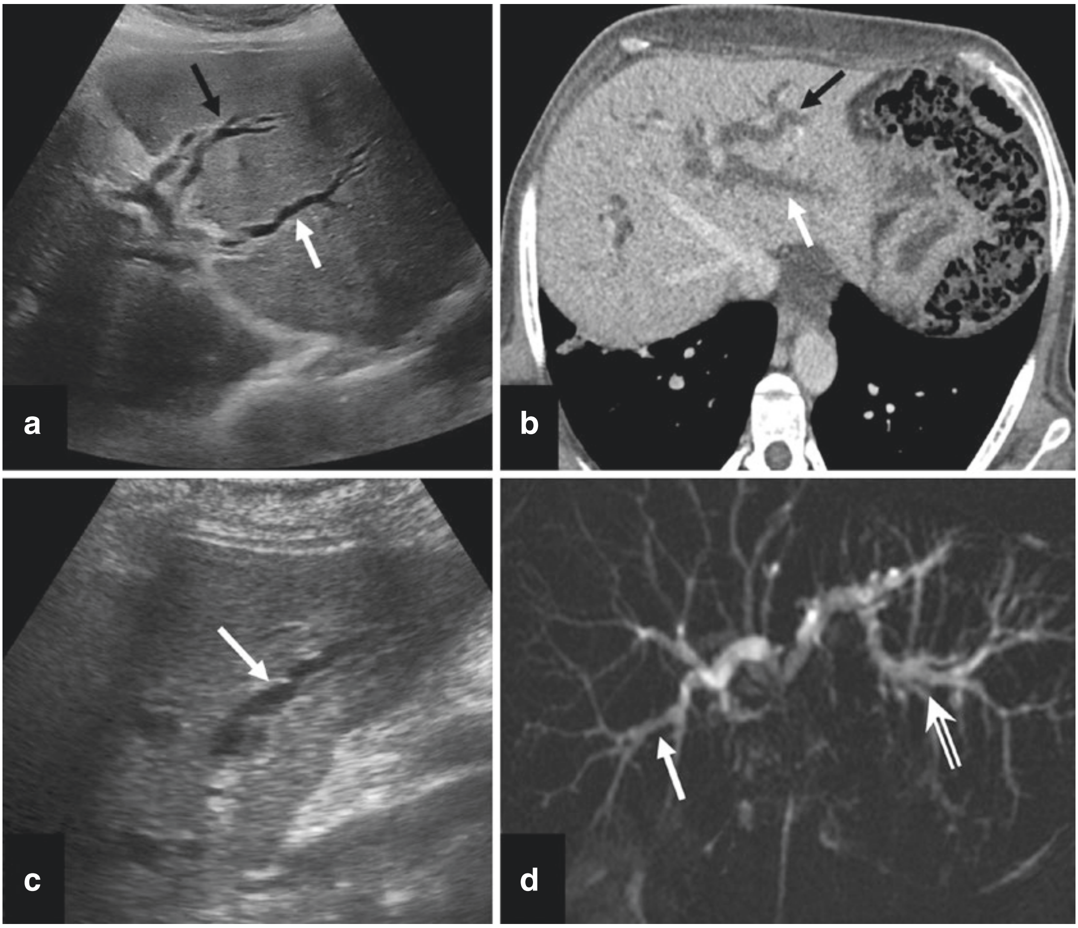

Fig. 2.4 Anatomy of segmental bile ducts of the liver. (**a, b**) Ultrasonography (**a**) and oblique axial CT scan (**b**) shows the relation of segment 2 (white arrow) and segment 3 (black arrow) ducts in the left lobe. Note that segment 3 duct is superficial and easier to puncture. (**c**) Ultrasonography of right lobe of the liver shows the segment 6 duct (white arrow) which is easier to puncture for right PTBD under ultrasonographic guidance. (**d**) MRCP image shows the preferred segment 3 duct (open arrow) and right posterior duct (arrow) for puncture as they form a smooth curve with common bile duct

2.4.6.5 Initial Puncture

Once the part is ready, it is important to identify a peripheral bile duct for puncture. Usually, the segment 3 duct on the left side and the segment 6 duct on the right side is preferred, as they are superficial and form a smooth curved course with the common bile duct (CBD) (Fig. 2.4) [6]. Segment 3 duct is superficial and more in line with the puncture compared to the segment 2 duct. Nevertheless, any duct may be punctured for drainage depending on the situations and the IR specialist's preference.

The puncture is best done under USG guidance (Figs. 2.5 and 2.6). Some may prefer to do it under fluoroscopic guidance as well. The USG probe is positioned in such a way that a 3–4 cm length of the duct is visualized. The point of puncture of the duct is important. Too peripheral puncture will result in the liver being pushed during manipulations, thus increasing the difficulty of the procedure. More central puncture increases the risk of hemorrhagic complications due to proximity to central vasculature. A reasonable site would be somewhere close to the

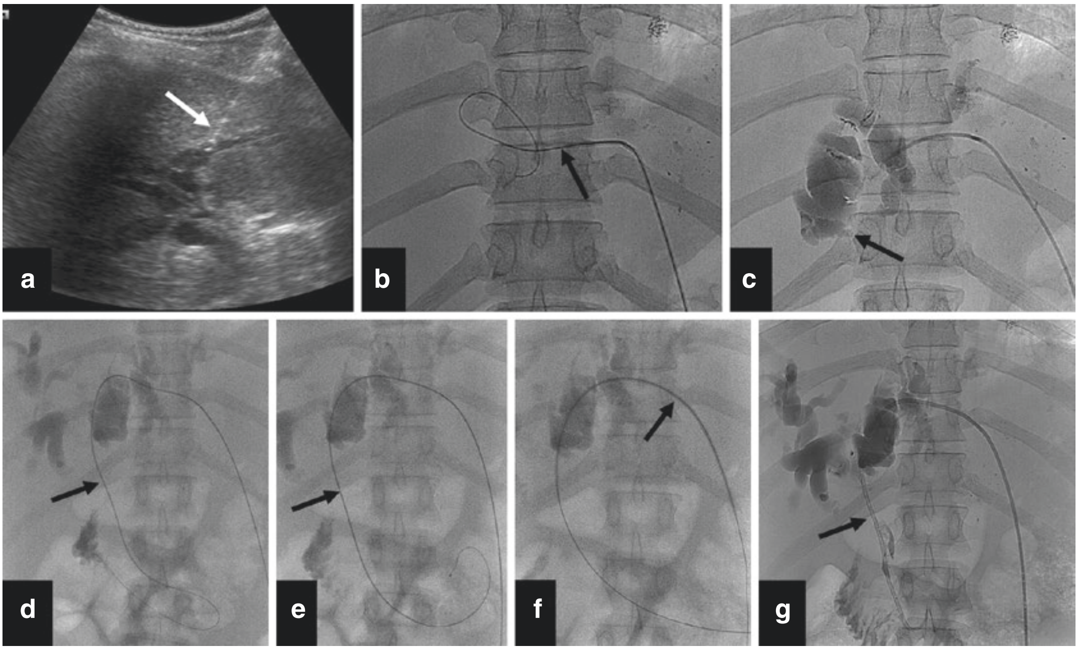

Fig. 2.5 Standard left PTBD. (**a**) Initial USG guided puncture (arrow) of segment 3 duct. (**b**) Exchanging the needle for 5F catheter (arrow) over a soft guidewire. (**c**) Initial cholangiogram showing the level of obstruction (arrow). (**d**) Soft guidewire (arrow) used to cross the stricture. (**e**) Extrastiff guidewire (arrow) replacing the soft guidewire. (**f**) Dilatation of the tract (arrow) and stricture. (**g**) Ring biliary catheter (arrow) allowing internal and external drainage

midpoint of the dilated segmental duct to be punctured, ensuring adequate surrounding parenchyma is present.

An 18G, 10 cm long, two-part needle is used for puncturing the duct. If the duct is only minimally dilated, a 21G or 22G needle should be used for the puncture. After the skin site is incised with a small surgical blade (No 11), the needle is advanced into the liver parenchyma toward the identified bile duct, under USG guidance. Once the needle tip is inside the duct, the trocar is removed to check for the backflow of bile. In an uninfected system, the bile is clear and light green in color. In infected cases, it is dark green and thick and may show debris or may be entirely purulent.

2.4.6.6 Cholangiogram

Once there is backflow of bile, a cholangiogram may be done at this point. However, it is not suggested, as there is a risk of displacement of the needle tip during this process. Hence, it is better to exchange the needle to a 5F catheter or 6F dilator over a soft hydrophilic guidewire (0.035 or 0.018 inch depending on the puncture needle used). This allows a longer length of the device (catheter or dilator) within the bile duct with secure access and thus less risk of displacement (Fig. 2.5b) [1]. Then a cholangiogram is done to identify the location and morphology of the obstruction (Figs. 2.5c and 2.6b).

While doing a cholangiogram, minimal diluted iodinated contrast should be used and contrast is injected gently and slowly to avoid it spilling into the obstructed undrained system. If it leaks, then there is a risk of chemical cholangitis caused by iodine itself. In cases of PTBD done for cholangitis, the use of contrast should be avoided, if possible or minimal contrast should be used to avoid bacteremia.

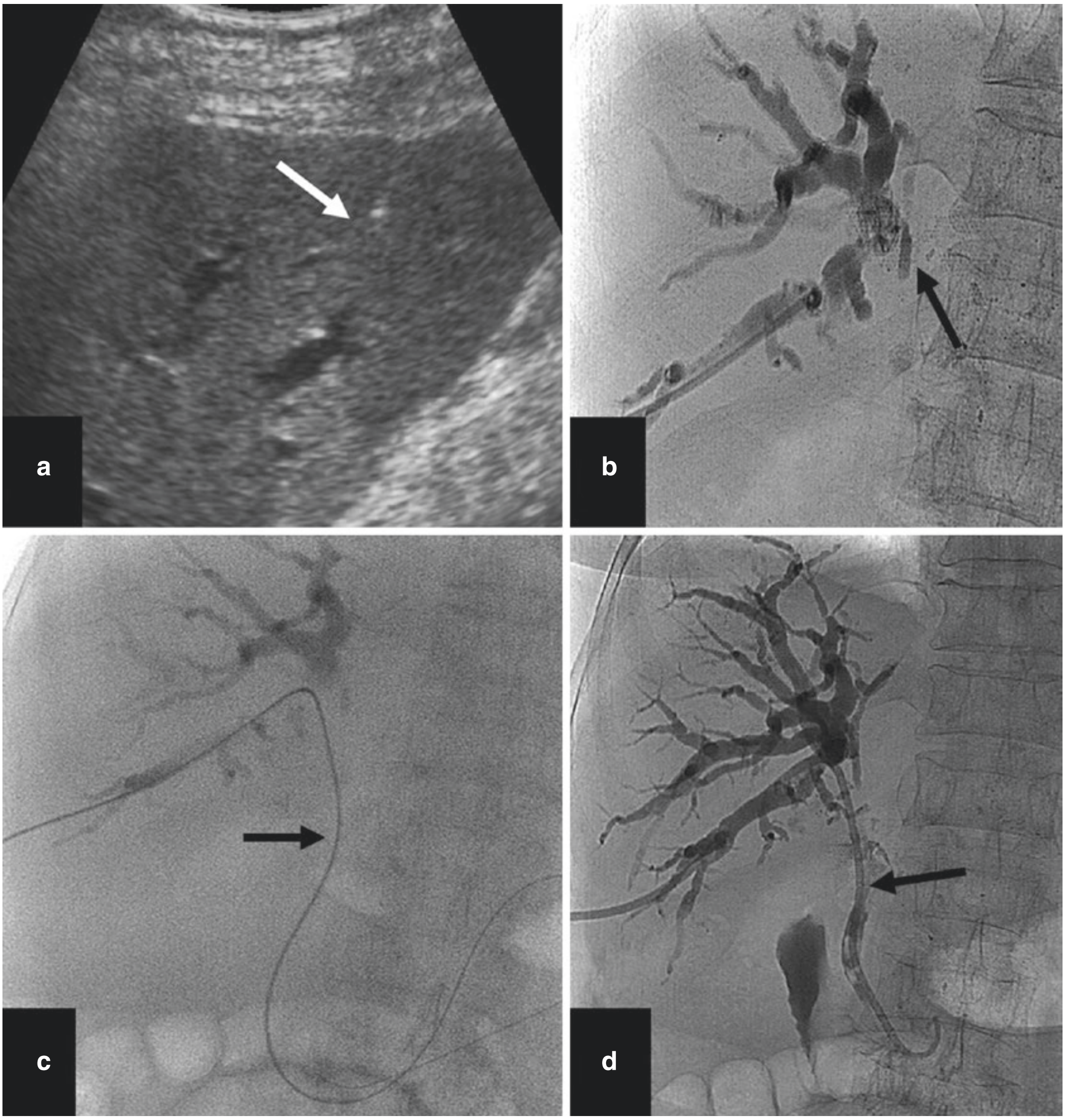

Fig. 2.6 Standard right PTBD. (**a**) Initial USG guided puncture (arrow) of segment 6 duct. (**b**) Initial cholangiogram with 5F catheter showing the level of obstruction (arrow). (**c**) Soft guidewire (arrow) used to cross the stricture. (**d**) Ring biliary catheter (arrow) allowing internal and external drainage, placed over an extrastiff guidewire

2.4.6.7 Crossing the Stricture (Internalization)

After localizing the level of obstruction with cholangiogram, the initial catheter or dilator is exchanged for a 5F KMP/multipurpose catheter (cut to a shorter length of about 35–40 cm) over a guidewire. With the tip of the catheter at the level of obstruction, J-tipped soft hydrophilic guidewire is used to cross the stricture (Figs. 2.5d and 2.6c). With a few attempts, the stricture can be crossed and the wire is passed through the ampulla into the third part of the duodenum. The catheter is pushed over the wire into the duodenum and the soft wire is exchanged for extrastiff or ultrastiff guidewire (Fig. 2.5e). The catheter is removed, leaving the wire in place.

In cases where the morphology of obstruction is rounded or when the dilatation is much, crossing the stricture may not be possible. Then, the stiff guidewire is passed into the bile duct, proximal to the obstruction, for an external drainage. Internalization should be attempted at a later date. Once the biliary system decompresses, which usually occurs in about a week, it is less roomy and less inflamed. This results in a successful internalization in most cases.

2.4.6.8 Tract and Stricture Dilatation

After the stiff wire is in place, the tract and the stricture are dilated serially, initially with 6F and then with 8F dilators (Fig. 2.5f). Since the final catheter to be placed is of 8F or 8.3F, dilatation with 8F dilator is sufficient. But, occasionally, if the stricture is hard, over dilatation with 9F or 10F dilator may be needed. Over dilatation should usually be done if the final catheter does not easily slide over the wire across the stricture as over dilatation may have a potential risk of pericatheter leak.

Similarly, where the stricture has not been crossed, only the tract is dilated with 6F and 8F dilators over the stiff guidewire.

2.4.6.9 Placement of the Catheter

After dilating the tract, an 8.3F ring biliary catheter (for combined external and internal drainage) is placed over the wire, with few holes proximal as well as distal to the stricture (Figs. 2.5g and 2.6d). The position is confirmed by injecting iodinated contrast slowly so that the location of the proximal holes is clearly visualized. It is important to ensure that there are adequate number of holes proximal to the obstruction within the duct and there are no holes in the hepatic parenchyma. If so, the position should be adjusted over the stiff guidewire and reconfirmed with contrast. In cases where the stricture could not be crossed, an 8F pigtail catheter is placed for external drainage. In both cases, the free flow of bile should be seen from the catheter. Finally, the hub of the catheter is connected to a drain bag.

2.4.6.10 Catheter Fixation and Dressing

After satisfactory position of the catheter is confirmed, it should be fixed to the skin. Since these catheters are placed for a long time, especially in situations where PTBD is done for palliative purposes, adequate fixation is critical to prevent its dislodgement (Fig. 2.7). It is usually done with 2–0 suture (silk), which is used to suture the catheter to the surrounding skin. A stay suture may also be applied to further ensure its stability. Then, a small piece of gauze is placed at the skin site, surrounding the catheter over which stick tapes are applied. A technique that is followed is to place a pair of stick tapes on either side of the catheter, extending to the skin, to reduce the chances of dislodgement (Fig. 2.7b). Few fixation devices are also commercially available and avoid placement of suture, however, these require changing after few weeks (Fig. 2.7c).

2.4.6.11 Post-Procedure Monitoring

After the procedure, the patient should be observed for 4–6 h. The vital parameters should be continuously monitored. The drain and the dressing should be observed for any bleeding. Bloodstained bile may be seen after the procedure, which clears over 12–24 h. The dressing should also be observed for any soakage from bile. If the patient is stable after 6 h, he or she may be discharged. If PTBD is done for cholangitis, the patient should remain admitted until he or she is fit to be discharged.

2.4.6.12 Patient Instructions

At the time of discharge, few instructions should be given to the patient. These include:

1. Taking proper care of the catheter.
2. Monitor output from the catheter.
3. Adequate fluid intake to match for the bile loss.
4. To visit the hospital on the said date for internalization/capping of the catheter.
5. To visit the hospital in cases of fever, pericatheter leak, reduction in the drain of bile, blood in the drain, and blood-soaked dressing.

2.4.6.13 Capping

Once the stricture has been crossed (in first or subsequent attempts) and a ring biliary catheter is placed, the external end of the catheter should be closed or capped (Fig. 2.7d). This allows internal

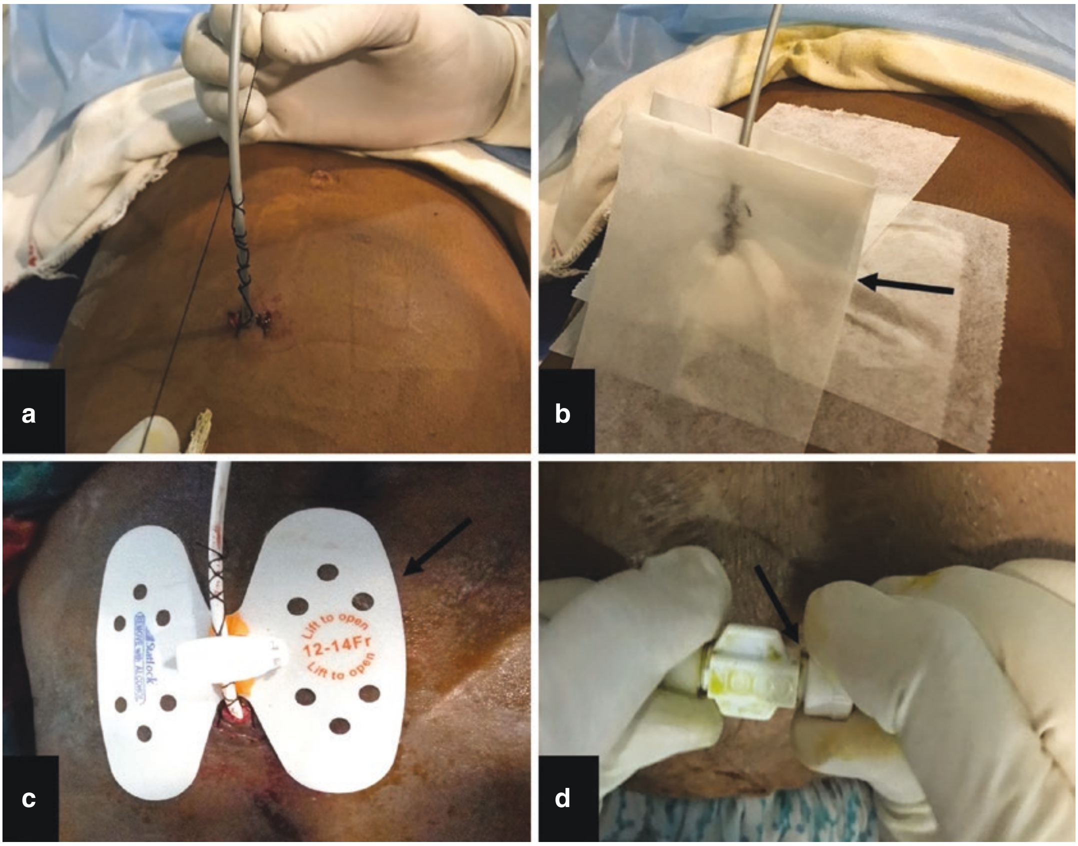

Fig. 2.7 Fixing the catheter. (**a**) Fixing the catheter with suture (2–0 silk). (**b**) Stabilizing the catheter with adhesive tapes (arrow). (**c**) Fixation device (arrow) used to fix catheters to skin. (**d**) Capping the ring biliary catheter (arrow) allowing internal drainage

drainage of the bile into the intestine allowing physiological drainage. External drainage results in loss of fluids and electrolytes, which should be balanced by adequate fluid intake. Once the catheter is capped, the drainage bag is not needed, which further improves the catheter's stability. Hence, internalization and capping of the catheter should be the aim of PTBD for malignant diseases as they are kept for a long duration.

Depending on the patient's requirement, morphology of the stricture, extent of hilar ducts involved and technical difficulty, unilobar or bilobar, and external or internal drainages are done (Fig. 2.8). Attempts should always be made to internalize the catheter. Multiple attempts (up to 5) may be necessary for some strictures with a gap of 1–2 weeks between two attempts.

2.4.7 Complications and Management

Since it is an invasive procedure, complications do occur. The incidence of the complications is in the range of 3–10% and mortality is very rare, with an incidence of <1% [10]. They can be classified into immediate and late. Immediate complications are the ones that occur within 48 h of PTBD. Late complications occur after 48 h. Any of the following complications can occur in the immediate or late period.

Bleeding—The incidence of significant bleeding is in the range of 2–2.5% in large centers [11]. The factors increasing the incidence of bleeding are renal failure, antiplatelet agents, multiple passes, central puncture, non-dilated

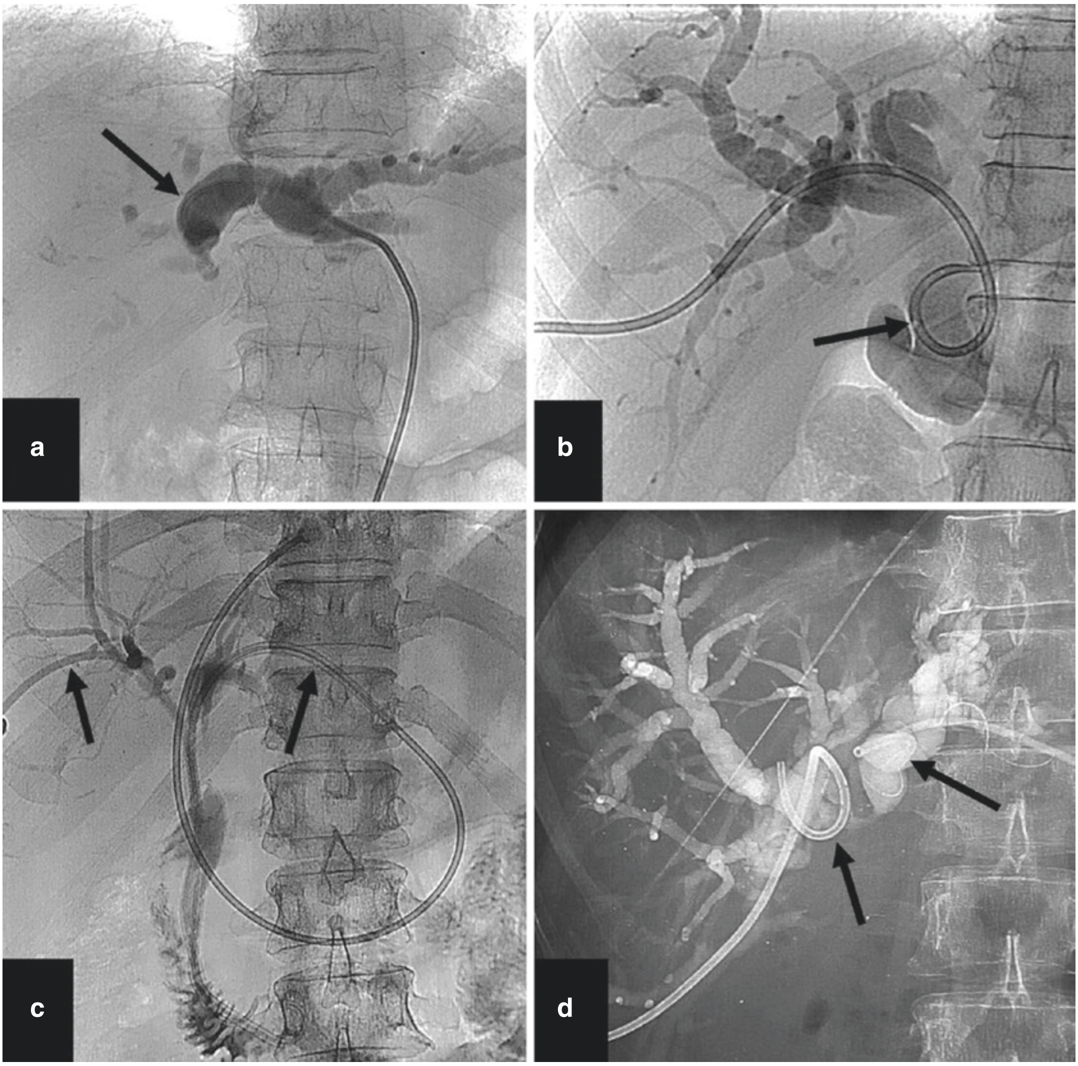

Fig. 2.8 Different types of drainage. (**a**) Left external drainage with pigtail catheter (arrow). (**b**) Right external drainage with pigtail catheter (arrow). (**c**) Bilateral external–internal drainage with ring biliary catheters (arrows). (**d**) Bilateral external drainage with pigtail catheters (arrows)

ducts, cirrhosis, and advanced age [12]. Majority of the bleeding complications (blood in the drain/hemobilia or pericatheter bleeding) are self-limiting. The patient should be observed for 24–48 h with the monitoring of vital parameters and gastrointestinal bleeding. The presentation is in the form of blood in drain, pericatheter bleeding, hematemesis or melena, or silent, when blood collects in the cavity like peritoneum, hepatic subcapsular space or pleural cavity. If the bleeding is persistent or if there is tachycardia or hypotension, the patient should be evaluated. After stabilization of the patient with blood products and intravenous fluids, the first thing to be done is a cholangiogram with iodinated contrast agent, to see if there are any holes of the catheter in the portal or hepatic vein or if there is any communication of the biliary system with hepatic artery or portal vein branches (Figs. 2.9 and 2.10). If holes of catheter are abnormally placed, it should be repositioned (Fig. 2.10a). If hepatic artery is opacified, then, depending on the

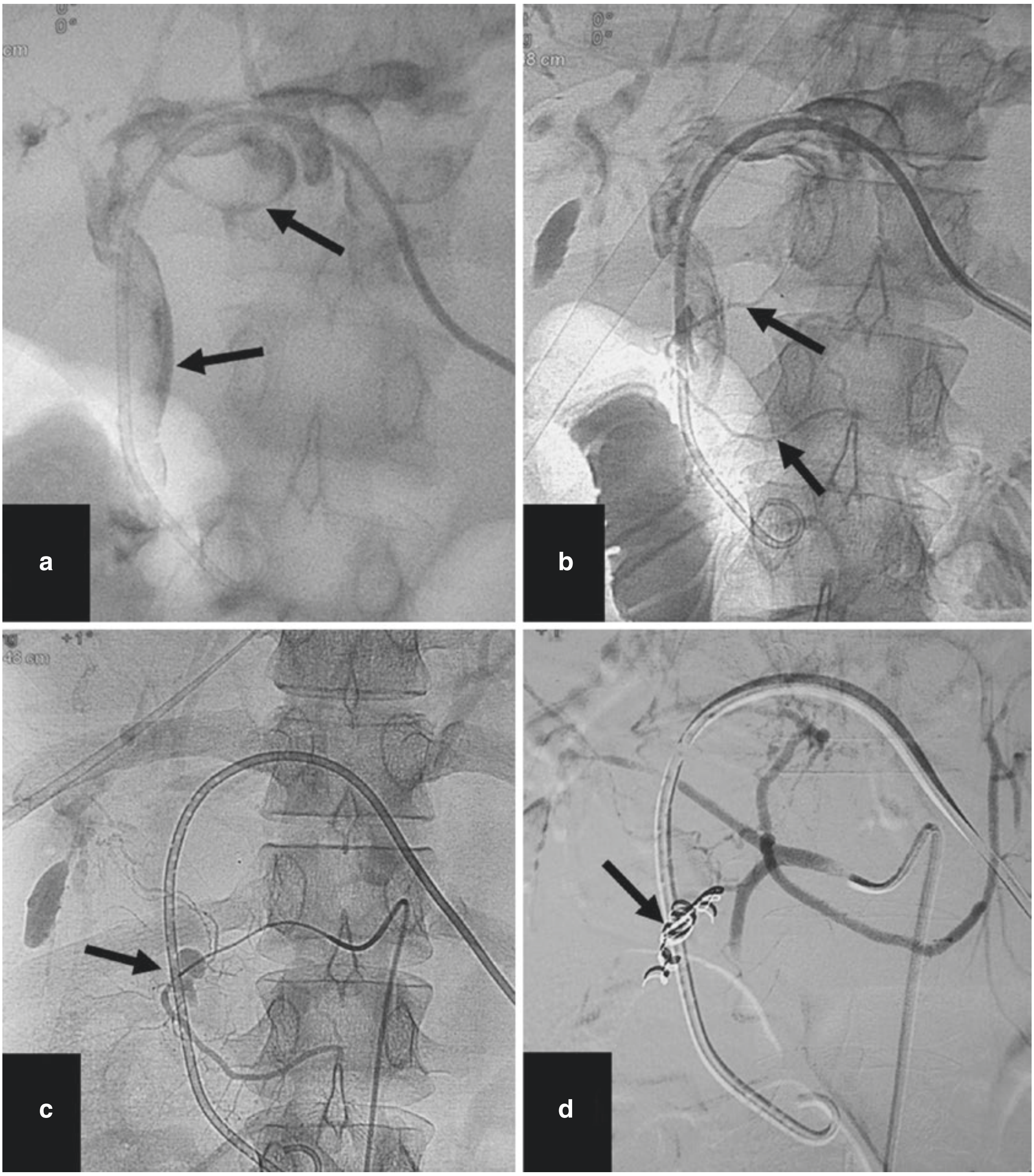

Fig. 2.9 Arterial injury. 30-year-old male presenting with bleeding from the ring biliary catheter, 1 week after PTBD. (**a**) Cholangiogram shows multiple filling defects (arrows) within the bile ducts suggesting clots. (**b**) On further contrast injection, gastroduodenal artery is seen opacified (arrows) close to the catheter. (**c**) Angiogram of gastroduodenal artery shows bilobed pseudoaneurysm (arrow). (**c**) Digital subtraction angiography shows embolization of the pseudoaneurysm with microcoils (arrow)

patient's condition, a CT angiogram followed by DSA or a DSA directly should be done (Fig. 2.9c). The bleeding artery should be catheterized selectively and embolized with coils (Fig. 2.9d) or n-butyl cyanoacrylate (NBCA). If portal vein is opacified, the management depends on the level of communication. If it is in the periphery, simple clamping of the catheter will cause the tampon-

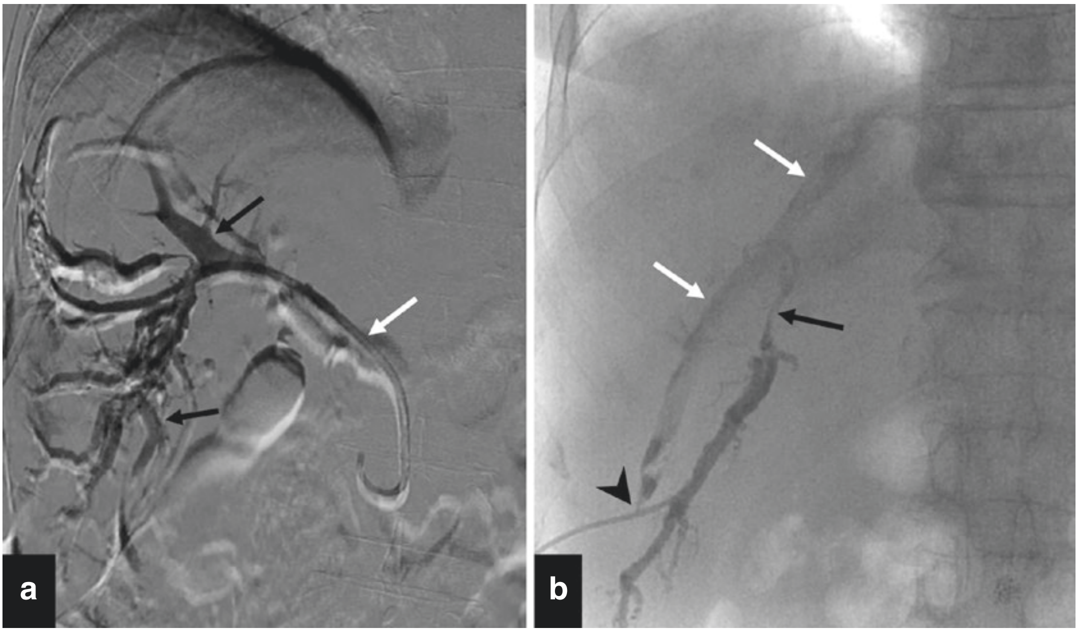

Fig. 2.10 Venous injury. (**a**) Cholangiogram shows opacification of portal vein branches (black arrows) suggesting bilio-portal fistula due to proximally displaced ring biliary catheter (white arrow). (**b**) Cholangiogram shows opacification of right hepatic vein (white arrows) due to pericatheter leak (arrowhead) around a 5F pigtail catheter which as passed through the hepatic vein

ade effect and stop bleeding as it is a low pressure system. If the communication is central, clamping may not stop the bleeding. Then, a covered stent should be placed in the biliary system or the portal vein to close the biliovenous fistula and to control bleeding [13]. If the cholangiogram does not show any vascular opacification, CT angiogram will be required to identify the source of bleeding. CT angiogram may show hepatic artery pseudoaneurysm, catheter eroding into the artery or an arterio-biliary fistula, or uncommonly, pseudoaneurysms of intercostal or superior epigastric arteries, all of which requires embolization. If the bleeding occurs after 48 h, the patient's coagulation parameters need to be evaluated along with radiological assessment, as it may be deranged, especially in patients with sepsis.

Fever—this indicates cholangitis, often due to the procedure itself and caused by manipulation of the infected biliary system, introduction of infection, and injection of more contrast. This should be treated by intravenous (admitted patient) or oral (outpatient) antibiotics and intravenous fluids. If the catheter has been capped, it should be opened and connected to a bag to drain the infected bile externally. The catheter can then be capped after a week. Although cholangiogram during this period should be avoided, it is often important to assess the position of the catheter. Partial dislodgement of the catheter results in inadequate internal drainage and thus cholangitis (Fig. 2.11a, b). Hence, with cholangiogram, any displacement will be identified and can be corrected. It may also identify cholangitic abscesses (Fig. 2.11c). USG should be done to look for any undrained biliary system, which may need drainage or any collections or bilomas which may be infected (Fig. 2.11d).

Pericatheter leak of bile—this usually indicates displacement or occlusion of the catheter (Fig. 2.12). Cholangiogram should be done to assess the position of the catheter. The catheter may be put on external drainage for a week to clear it of sludge and debris. Ascites, if present, may be a cause of pericatheter leak and should be drained. If the leak continues despite these mea-

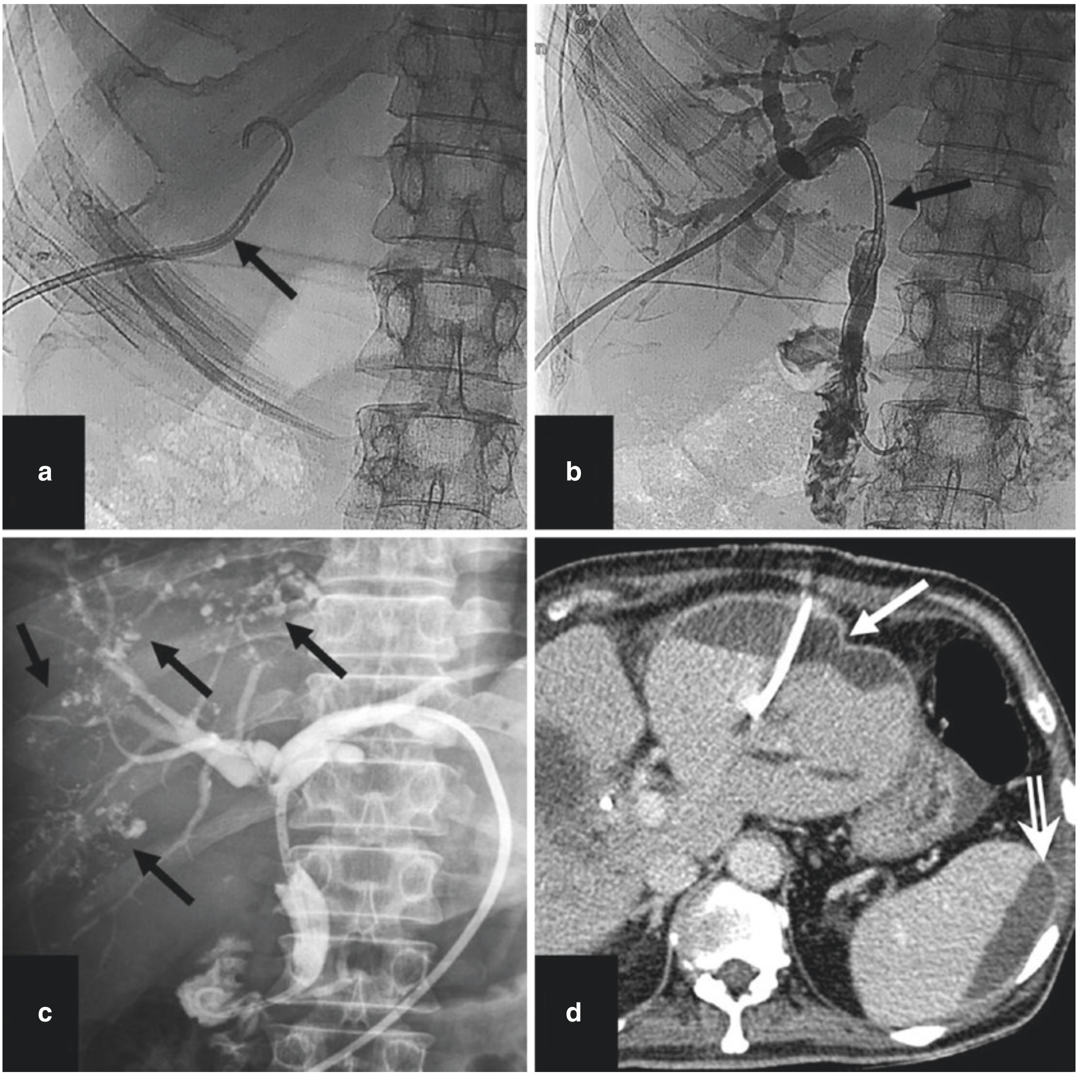

Fig. 2.11 Other complications of PTBD. (**a, b**) Displacement of ring biliary catheter. (**a**) Radiograph shows displaced ring biliary catheter (arrow). (**b**) Repositioning of the catheter to its appropriate position (arrow). (**c**) Cholangitis. Cholangiogram shows multiple small fluffy opacities (arrows) suggesting cholangitic abscesses. (**d**) Biloma. CT scan shows biloma formation in perihepatic (white arrow) and perisplenic (open arrow) regions due to pericatheter bile leak

sures, then the catheter should be upgraded, from 8F to 10F or 10F to 12F. If the leak persistently occurs with 12F, then a colostomy bag may be placed around the capped catheter to collect the leaked bile.

Catheter-related problems—since the catheter is left for a longer duration, problems like catheter displacement, complete dislodgement, and fracture are not uncommon (Figs. 2.11 and 2.12). If complete displacement occurs in the immediate period, repeat PTBD should be done. But, it is often difficult as the biliary system is likely to be decompressed. Depending on the extent of dilatation, immediate need for drainage and IR specialist's expertise, repeat PTBD may be done either immediately or later, when the dilatation is adequate. If catheter is pulled-out in a later period (after 2 weeks), the tract is usually mature.

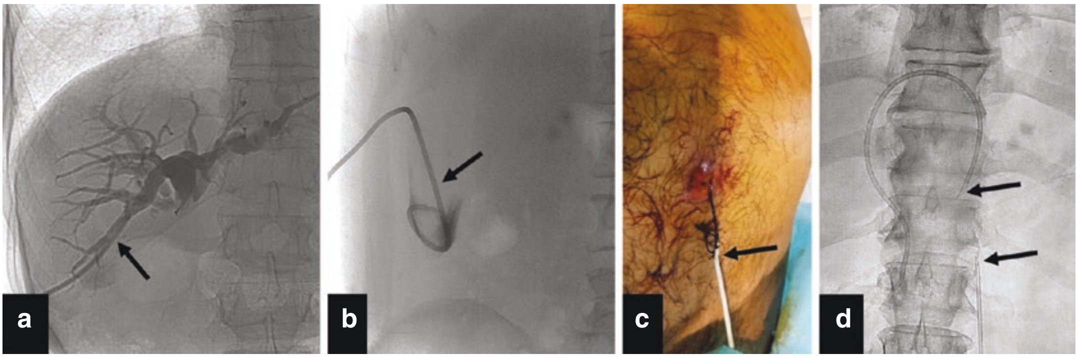

Fig. 2.12 Catheter-related complications. (**a**, **b**) Displaced catheter. After initial external drainage with pigtail catheter (arrow in **a**), patient presented 2 days later with non-draining of bile. Cholangiogram (**b**) shows a displaced catheter lying in the peritoneal cavity (arrow in **b**). (**c**, **d**) Catheter fracture. Clinical picture (**c**) and radiograph (**d**) shows the fractured ring biliary catheter with fractured ends (arrows)

Probing the tract with soft hands, using a 6F dilator/MPA catheter and J-tipped soft hydrophilic guidewire, will allow access into the biliary system, after which further steps of PTBD are followed and catheter is placed. Partial displacement of catheters should be repositioned under fluoroscopy guidance and cholangiogram (Fig. 2.11a, b). If there is a fracture of the catheter, it should be replaced. The catheter may get occluded with sludge over time and it is suggested that the catheter be exchanged every 6–8 weeks.

Pleural complications are uncommon and seen with right-sided PTBD and are in the form of pneumothorax or hemothorax. Symptomatic patients may need intercostal tube drainage.

Bile leak may occur infrequently, often due to catheter displacement, and may lead to biloma formation (Fig. 2.11d) and rarely, biliary peritonitis. Treatment is drainage of biliary collections and antibiotics.

Pancreatitis is seen in up to 1% of cases, usually due to the occlusion of the pancreatic ductal opening by the catheter or by a clot. It is usually mild, but occasionally, it may be severe.

2.4.8 Trouble Shooting

Unable to pass the initial access catheter or dilator over the soft wire—this is often seen in patients with long-standing obstruction (slow-growing tumors) or with recurrent cholangitis, where the wall of the ducts is thick and fibrous. One can try and pass a 4F catheter over the wire, which is often successful. If not, a vascular sheath (6F) could be inserted to bridge the space between the skin and the duct wall (Fig. 2.13). This prevents buckling of the catheter and allows its passage over the wire. If this also fails, a stiff dilator (usually 8F) may be pushed over the wire, with the aim of widening the puncture hole in the wall of the duct. In most cases, these measures help.

Unable to cross the stricture—this occurs mostly when the dilatation is moderate to gross and it is difficult to guide the wire through the stricture. It is better to allow external drainage and attempt after a week (Fig. 2.14). This will make the system less roomy and reduces the inflammation, which will allow the wire the pass in majority of cases. It is suggested that for all crossing, a J-tipped soft guidewire is used. A straight tip wire, although may be used, will invariably create a false tract leading to a failed attempt at internalization.

Stiff wire is across the stricture, unable to pass the catheter or dilator—this typically happens when the stricture is due to a hard fibrous mass. To pass the catheter, a vascular sheath (6F) can be used to bridge the gap, as described above (Fig. 2.13). If it is difficult to pass dilator across the stricture, there are two options. One is placing an external drainage catheter and attempting internalization later, after a week.

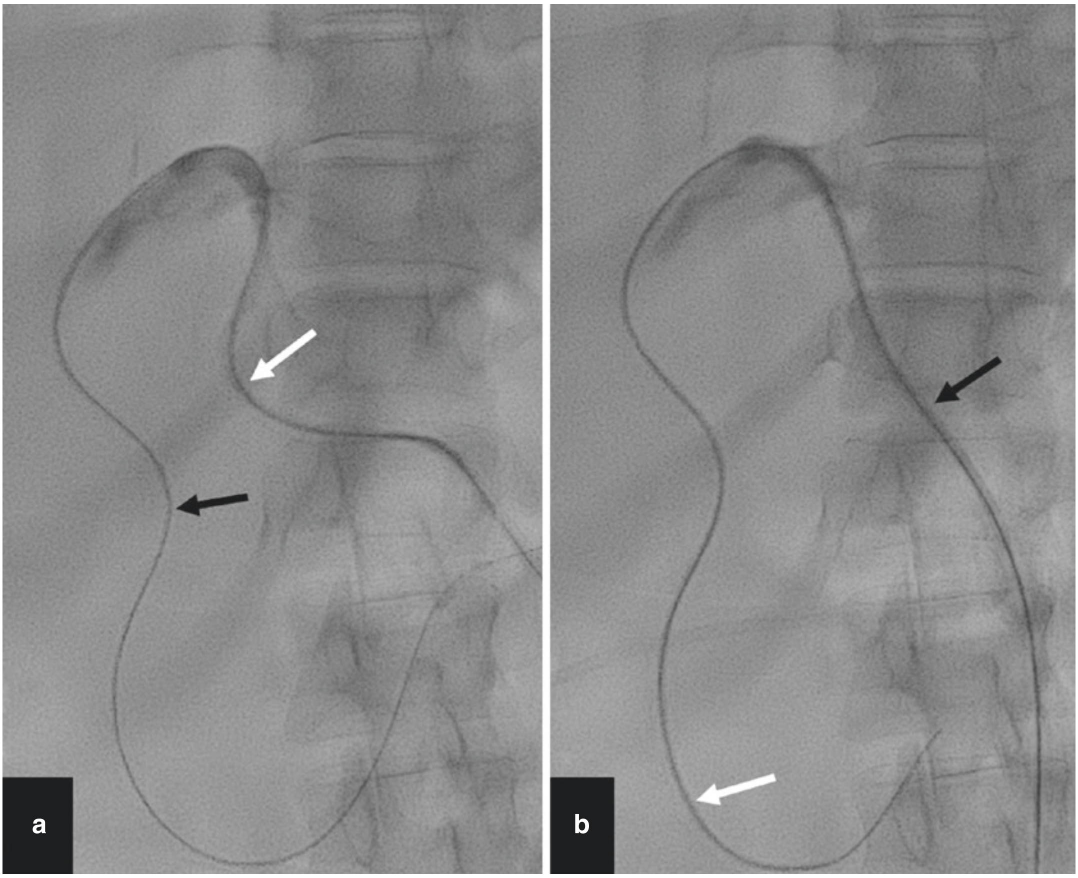

Fig. 2.13 Trouble shooting—support of sheath. (**a**) The 5F catheter buckles (white arrow) due to the resistance at stricture level (black arrow) despite the extrastiff guidewire. (**b**) Placing a vascular sheath (black arrow) provides support, preventing buckling of the catheter and allowing it to slide over the guidewire across the stricture (white arrow)

The second option is to balloon dilate the stricture, using a 4–6 mm balloon catheter (Fig. 2.15a, b). However, this increases the risk of bleeding. Either option may be chosen depending on the preference.

Unable to dilate the tract—sometimes, the duct wall is thick due to repeated cholangitis and it would be difficult to push the dilator over a stiff wire. In such cases, a smaller caliber pigtail catheter (5F or 6F) may be placed for external drainage (Fig. 2.15c). This is then exchanged for 8F catheter after a week, during which time, the duct wall undergoes pressure necrosis by the smaller caliber catheter.

2.5 Biliary Stenting

2.5.1 Indications

Biliary stenting allows internal drainage of bile into the intestine. The main indication for it is malignant biliary stricture, in the palliative setting. The causes include gallbladder cancer, cholangiocarcinoma, pancreatic cancer, metastatic lymphadenopathy, and duodenal carcinoma. Since surgical removal of the stent is challenging, it should ideally be placed in inoperable malignancies. However, it is also indicated in benign diseases not manageable by routine treatments.

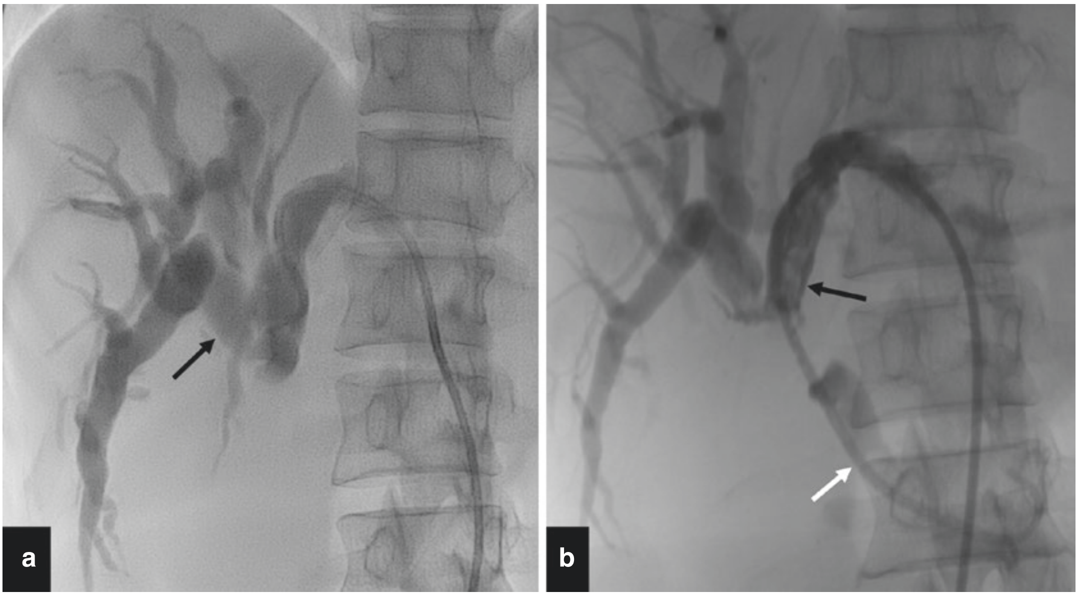

Fig. 2.14 Trouble shooting—Delayed internalization. (**a**) Cholangiogram at the time of PTBD shows gross dilatation of bile ducts (black arrow) causing failure of internalization. (**b**) Cholangiogram after a week shows partially decompressed bile ducts (black arrow) helping in internalization and placement of ring biliary catheter (white arrow)

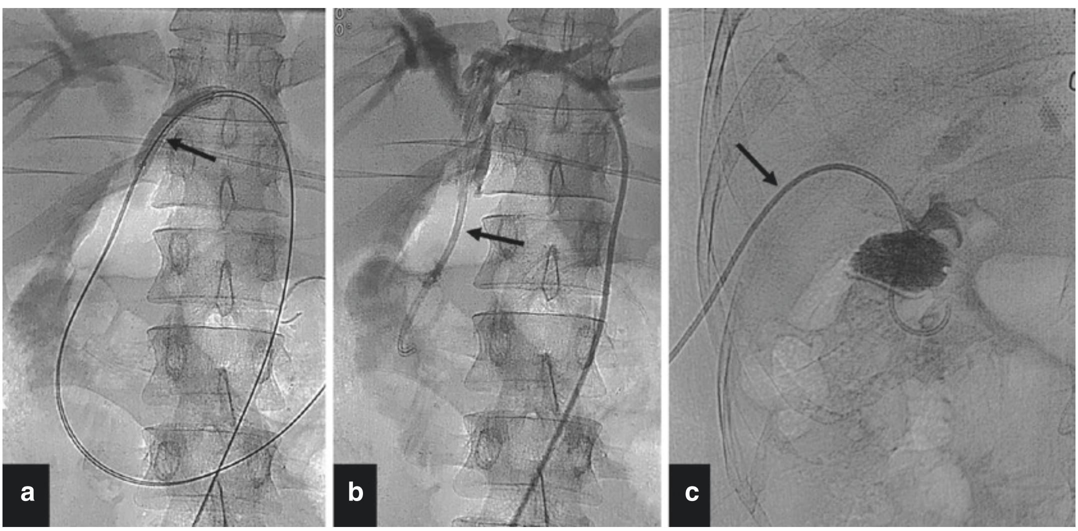

Fig. 2.15 Trouble shooting. (**a, b**) Cholangioplasty. (**a**) Balloon dilatation of the tight stricture due to cholangiocarcinoma using 6 × 40 mm balloon catheter (arrow). (**b**) Easy placement of ring biliary catheter after cholangioplasty (arrow). (**c**) Another case where a smaller caliber (5F) catheter was placed for external drainage due to difficulty in dilatation of the tract. After a week, 8F catheter placement is usually successful

2.5.2 Primary Versus Secondary Stenting

Biliary stent placement may be primary or secondary [14]. Primary stenting is when stent is placed during the initial procedure of PTBD. Secondary stenting is when the stent is placed in a subsequent session after a catheter PTBD is done. In both these settings, crossing the stricture is necessary, before a stent is placed.

Primary stenting is the preferred method in noninfected system. Secondary stenting adds to the cost in terms of additional procedure and radiation [15]. A benefit of secondary stenting is that planning is better once internalization has been done. However, secondary stenting should be done in patients presenting with cholangitis after complete resolution of the infection.

2.5.3 Procedure

Primary stenting requires admission of the patient and observation overnight after the procedure. However, for secondary stenting, admission is not necessary and may be done as a day care procedure.

Once the biliary stricture is crossed and a stiff guidewire is placed with tip in the duodenum (preferably third part for safety), biliary stent is placed (Fig. 2.16). Depending on the compatibility of the stent device, a vascular sheath (usually 6F) is placed into the biliary system over the wire. A cholangiogram through the sheath is useful to define the length of the stricture. The ideal position of the stent is to have at least 2 cm of the stent proximal and distal to the stricture. The stent device is inserted through the sheath, over the wire, and positioned such that the proximal and distal radio-opaque markers of the stent are optimal in relation to the stricture. Once in position, the stent is deployed. As soon as the stent expands, the pooled contrast proximal to the obstruction is seen to pass through the stent into the duodenum. Balloon dilatation of the stricture prior to stenting is not necessary as it does not alter complication or stent patency rates [14].

In most cases, the stent expands fully. If not, it expands over 24–48 h, once the stent reaches the body temperature. Routinely, an access catheter (5F catheter) is placed through the stent into the duodenum after removal of the sheath and kept for 48 h. The patency and expansion of the stent are rechecked after 48 h, using a vascular sheath. If it is satisfactory, then the catheter is removed. In case of partial expansion (> 60 to 70%) with free flow of contrast no balloon dilatation may be required. However, for <50% expansion or no free flow of contrast through the stent, balloon dilatation may be done using an undersized balloon catheter (Fig. 2.17). After dilatation, an access catheter must be left in situ and again reassessed after 48 h. In most cases, this is sufficient to expand the stent.

2.5.4 Types of Stents

Two common types of stents used are uncovered and covered [16].

The most commonly used stent is the uncovered self-expandable metallic stent (SEMS). The diameter of the stent is usually 10 mm for CBD and 8 mm for hepatic ducts. The length of the stent varies with the length of the stricture. One has to place the ends of the stent, 2 cm proximal and 2 cm distal to the ends of the stricture. If the stricture is long, two overlapping stents may be necessary.

Uncovered stents are usually preferred as they do not cause occlusion of the undrained ducts, cystic duct, and pancreatic duct [16]. Further, there is a very low chance of migration and the stent costs less than a covered stent. However, there is a higher incidence of tumor ingrowth, occluding the stent. On the other hand, covered stents improve stent patency by preventing stent ingrowth [17]. However, there are higher risks of cholangitis, cholecystitis, and pancreatitis due to occlusion of the ducts. The risk of migration and occlusion by sludge is also higher [18]. A modified covered stent with proximal and distal bare ends of about 2 cm each improves anchoring and helps in preventing migration [18]. Studies have, however, shown no significant difference in long-term patency and survival between the two stent types.

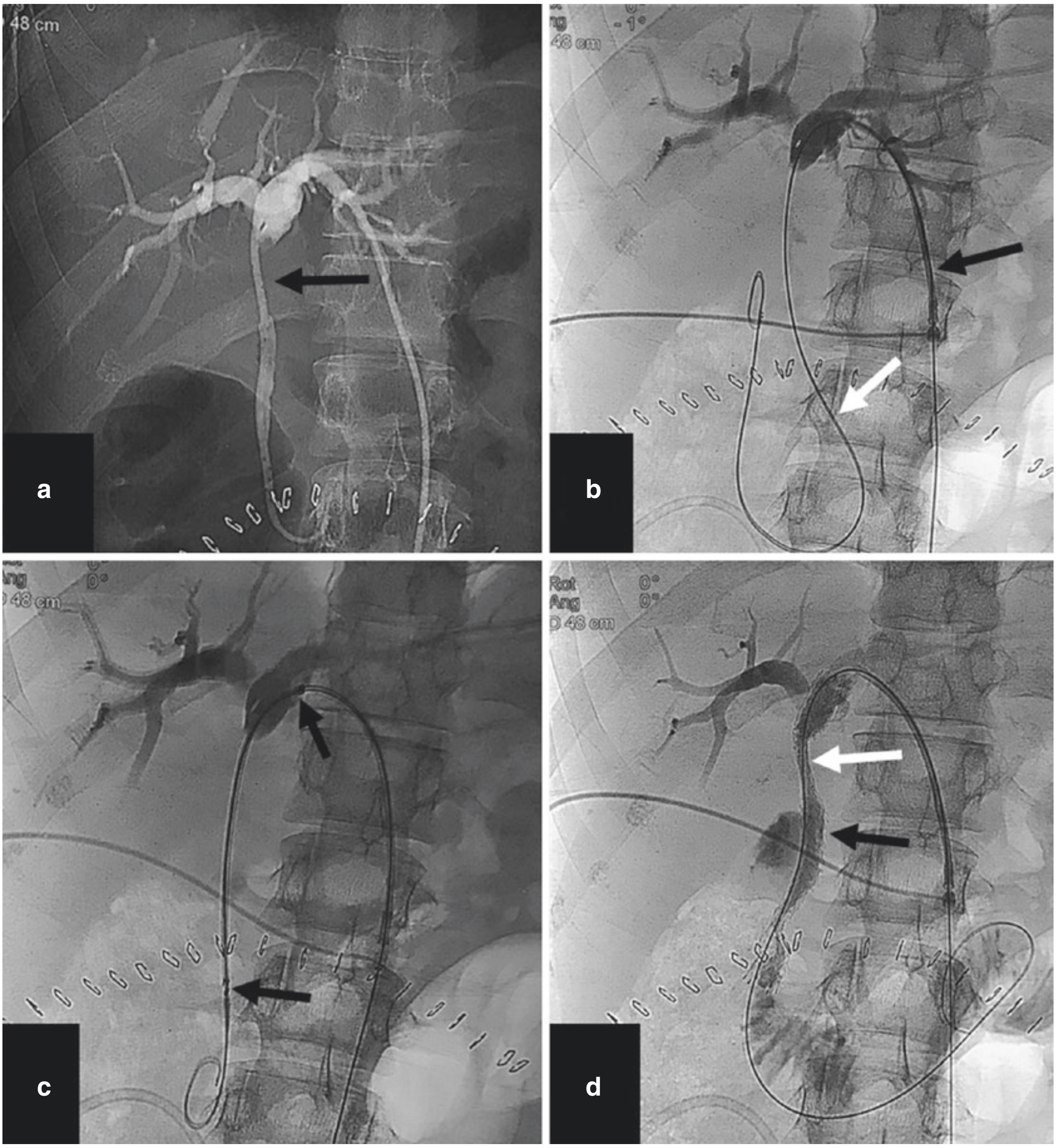

Fig. 2.16 Unilateral secondary biliary stenting. (**a**) Cholangiogram showing ring biliary catheter after internalization. (**b**) Placement of a vascular sheath (black arrow) over an extrastiff guidewire (white arrow). (**c**) Appropriate positioning of self-expandable metallic stent with the help of the platinum end markers (arrows). (**d**) Fully deployed stent (black arrow) with distal flow of contrast. The narrowing of the stent at the site of stricture (white arrow) usually expands over 24–48 h

2.5.5 Suprapapillary Versus Transpapillary Stent

For mid and distal CBD strictures, it is still not clear if the lower end of the stent should remain proximal to the ampulla (suprapapillary) or should cross the ampulla (transpapillary) (Fig. 2.18) [19]. Suprapapillary placement may cause dysfunction of the sphincter of Oddi (SOD) resulting in its spasm and reduced clearance of bile across it. Transpapillary stenting increases

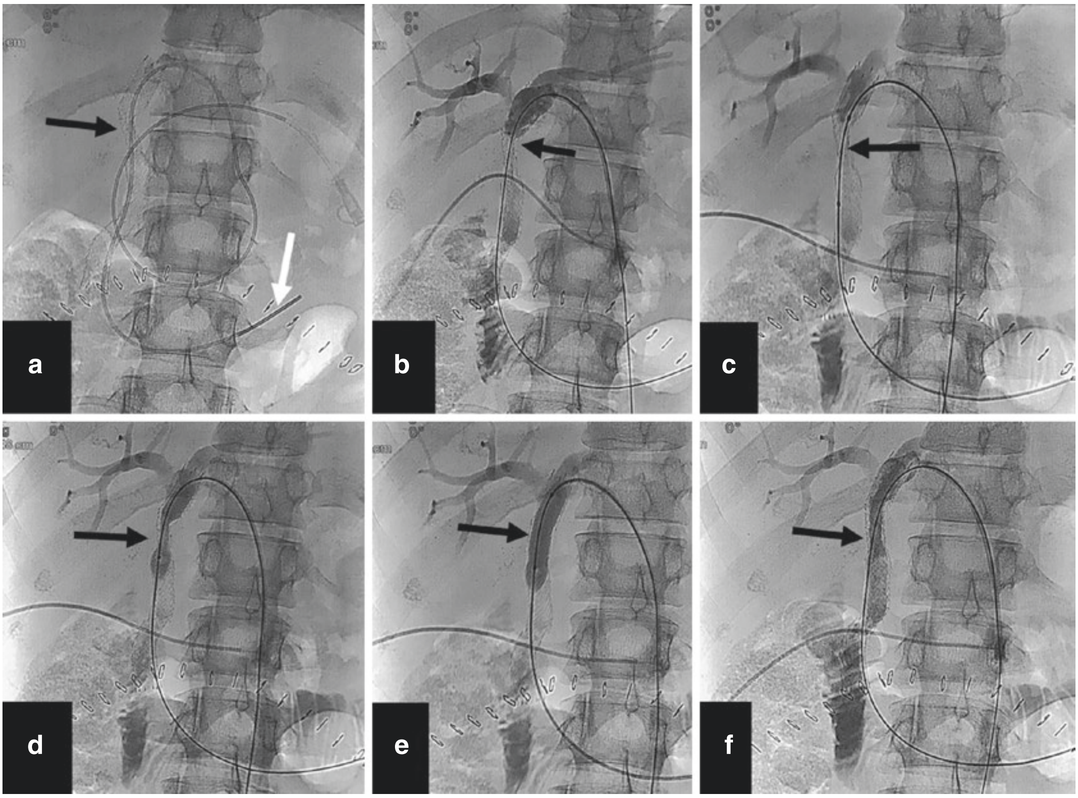

Fig. 2.17 Post-stenting balloon dilatation. (**a**) Radiograph shows fully expanded stent (black arrow) with 5F access catheter (white arrow). (**b**) Cholangiogram obtained using a vascular sheath placed over a wire shows restricted flow of contrast at the site of the tumor (arrow) with stasis. (**c**) Position of 10 × 40 mm balloon catheter across the obstruction with the help of radio-opaque markers (arrow). (**d**) On inflation of the balloon catheter, waist (arrow) is seen. (**e**) Fully expanded balloon catheter (arrow). (**f**) Post dilatation cholangiogram shows free distal flow of contrast across the tumor (arrow)

the risk of reflux of duodenal contents into the biliary system and thus cholangitis. It is suggested that transpapillary stenting should be done for distal bile duct strictures which show angulation at its junction with normal duct [19]. In a comparative study, it was shown that suprapapillary stent was associated with higher incidence of tumor growth, but lower incidence of pancreatitis and occlusion by sludge [20]. However, there was no difference in stent patency or patient survival between the groups.

2.5.6 Y or T stents

In cases of hilar obstruction, unilateral stenting is often sufficient for improving patient's symptoms due to biliary obstruction [21]. However, frequently, bilateral stenting may be necessary, especially if the serum bilirubin is not dropping or if the undrained system is infected [18]. This can be done by two methods [22].

Y stent—here, the biliary system is accessed through both sides (right and left) and wires are passed across the stricture into the duodenum (Fig. 2.19). Subsequently, two SEMS are deployed simultaneously to drain both biliary systems. This procedure requires additional drainage of the opposite biliary system.

T stent—here, the biliary system is accessed percutaneously through one side (right or left) (Fig. 2.20). Then, through this side, two soft hydrophilic guidewires are passed crossing the stricture, one to the bile ducts of the contralateral

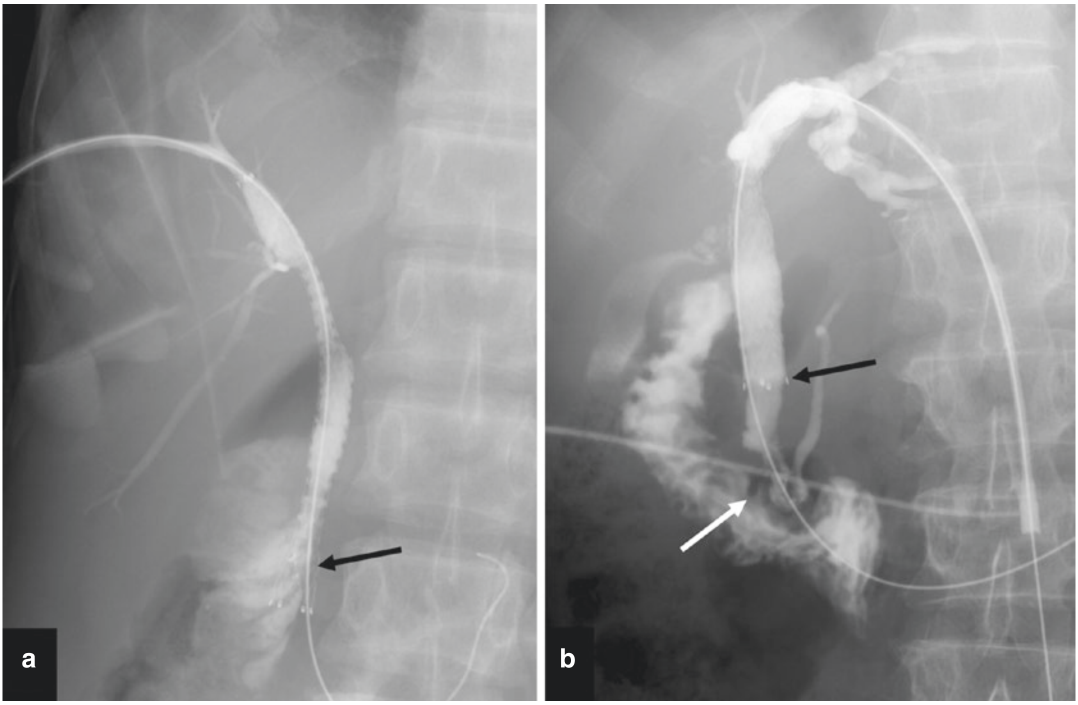

Fig. 2.18 Stent positioning. (**a**) Transpapillary (arrow) biliary stent placement. (**b**) Suprapapillary placement of stent with the lower end of the stent (black arrow) above the ampulla (white arrow)

side and the other into the distal CBD or duodenum. After exchanging these soft wires for stiff guidewires, SEMS (preferably 8 mm diameter) are passed over each wire and deployed.

2.6 Additional Procedures Through PTBD Route

2.6.1 Brush Cytology/Forceps Biopsy

Once the biliary system is accessed percutaneously, the same route may be used to obtain samples of tissue responsible for the obstruction [23]. The devices for cytology or biopsy are not over the wire (OTW) and hence a longer vascular sheath, which can reach the point of obstruction, is necessary. Once the tip of the sheath is at the tumor, the cytology brush or biopsy forceps is introduced through the sheath to obtain samples from the lesion. The sensitivity of brush cytology variably ranges from 40% to 75% [24]. The use of forceps biopsy or combination of cytology and biopsy improves the sensitivity of the sampling. This is especially useful in cases of biliary strictures where the mass is small and a standard method of sampling is not possible.

The initial procedure is similar to PTBD [25]. Once, the wire is across the stricture, a longer vascular sheath (6–8F) is placed with its tip just across the stricture (Fig. 2.21). Then the cytology brush or the biopsy forceps is passed through the sheath to enter the stricture. Then the brush is scraped over the stricture a few times, under fluoroscopy, and removed. The sample is then either spread on the slide or immersed in a bottle with fixative for pathological evaluation. If a biopsy forcep is used, samples of tissue are obtained from the stricture site and transferred to a bottle with fixative.

2.6.2 Endobiliary Radiofrequency Ablation

The PTBD tract may also be used to ablate the tumors causing biliary obstruction. Radiofrequency ablation (RFA) is one such technique. During

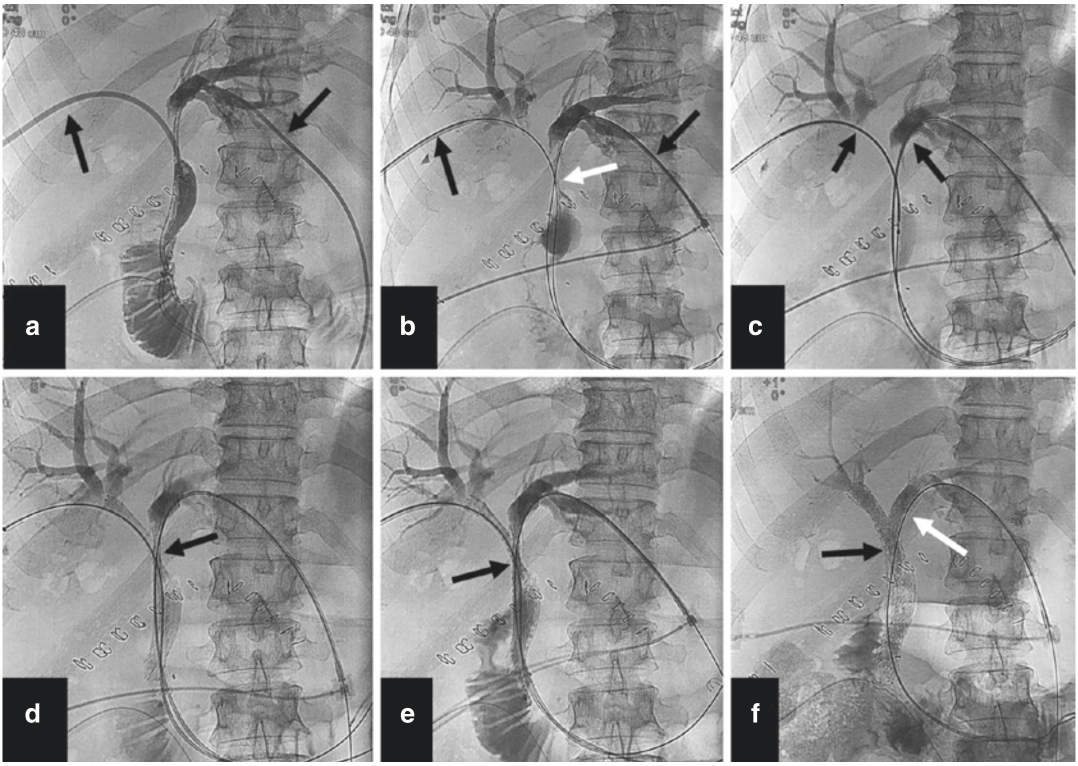

Fig. 2.19 Bilateral secondary stenting (Y stent). (**a**) Bilateral ring biliary catheters placed after internalization. (**b**) Cholangiograms from both sides after placement of the sheaths (black arrows) over extrastiff guidewires to define the stricture (white arrow). (**c**) Simultaneous positioning of self-expandable metallic stents (arrows; 8 × 100 mm) with the help of end markers. (**d**) Fully deployed bilateral stents across the stricture (arrow). (**e**) Cholangiogram from the left side shows partial expansion of the stents at the site of stricture (arrow). (**f**) Cholangiogram obtained from the left side (white arrow) after 2 days shows complete expansion of both stents at the site of stricture (black arrow) with free distal flow of contrast

PTBD, once the stiff wire has been placed across the stricture, the flexible RF probe is passed over the wire, through a sheath and positioned at the level of the tumor (Fig. 2.22) [26]. By applying adequate RF energy, the tumor can be ablated, without causing significant complications. After RFA, SEMS is usually placed. The same technique is frequently used to recanalize an occluded SEMS due to tumor ingrowth [27]. Post RFA, a balloon catheter is used to sweep down the debris into the duodenum. RFA has shown to improve the patency of the stents placed in palliative setting.

2.6.3 Endobiliary Brachytherapy

Similar to RFA, malignant biliary stricture may be treated with radiotherapy through the PTBD tract [28, 29]. This is usually indicated in patients with inoperable malignant biliary strictures due to locally advanced disease. It is better than external beam radiotherapy as higher dose of radiation can be given to a defined target area, without much affecting the surrounding normal tissues. Since around 1 cm of tissue is irradiated, it may improve stent patency.

Iridium-192 is used as the radiation source [29]. Once a catheter, 10F size, is placed across the stricture, the Iridium-192 pellets with applicator are inserted through the catheter and positioned across the stricture with 1–2 cm proximal and distal margins. High dose rate is commonly delivered. Post-procedure, the applicator is removed and the ring biliary catheter is left in situ.

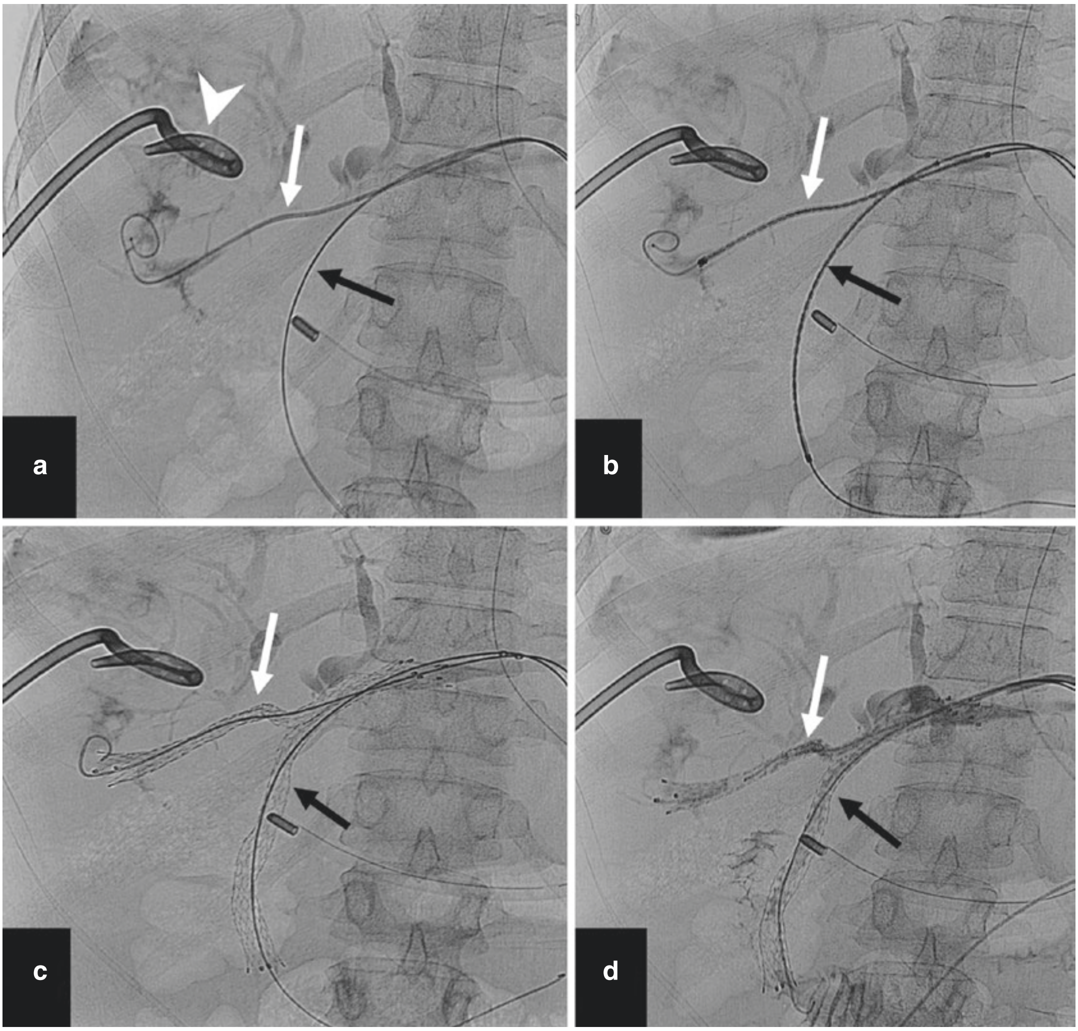

Fig. 2.20 T-stenting. 40-year-old female with gallbladder cancer-causing hilar obstruction and right lobar cholangitic abscess. (**a**) Fluoroscopic spot image shows two guidewires, one passing from left lobe to duodenum (black arrow) and the other from left lobe duct to right lobe duct (white arrow) along with a pigtail catheter in the abscess (arrowhead). (**b**) Positioning of the stents in T morphology, one from the left duct to the right duct (white arrow; 8 × 80 mm) and other from the left duct to duodenum (black arrow; 8 × 100 mm). (**c**) Fully deployed stents in T morphology (black and white arrows). (**d**) Cholangiogram shows free flow of contrast in both stents (black and white arrows)

2.7 PTBD for Benign Biliary Obstruction

Benign biliary strictures are frequently an indication for PTBD [30]. Although, in many cases, EBD is attempted, there are few specific situations where PTBD is the treatment of choice. Procedure is mostly similar to that described above, except for some minor variations and precautions. The follow-up protocol is different.

2.7.1 Clinical Presentation

Majority of these patients present with recurrent episodes of fever with chills due to recur-

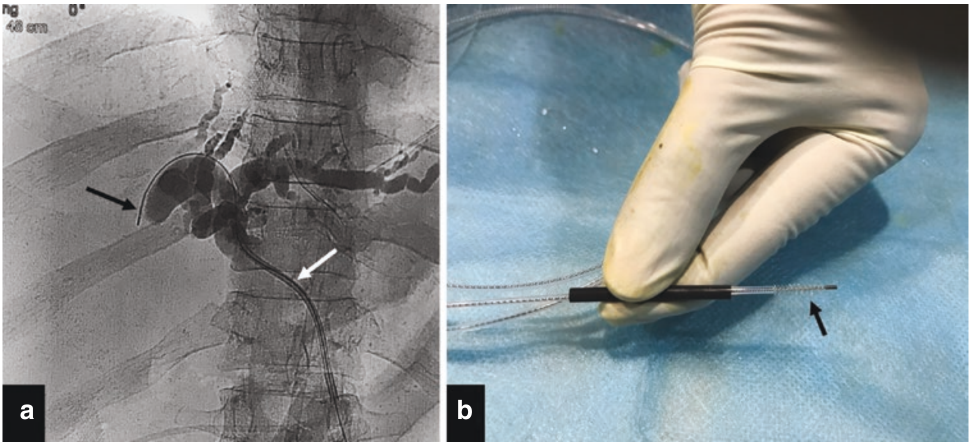

Fig. 2.21 Brush cytology. (**a**) Cytology brush (black arrow) positioned right at the point of stricture after pulling back the sheath (white arrow) to take sample. (**b**) Brush cytology device with thin bristles near its tip (arrow)

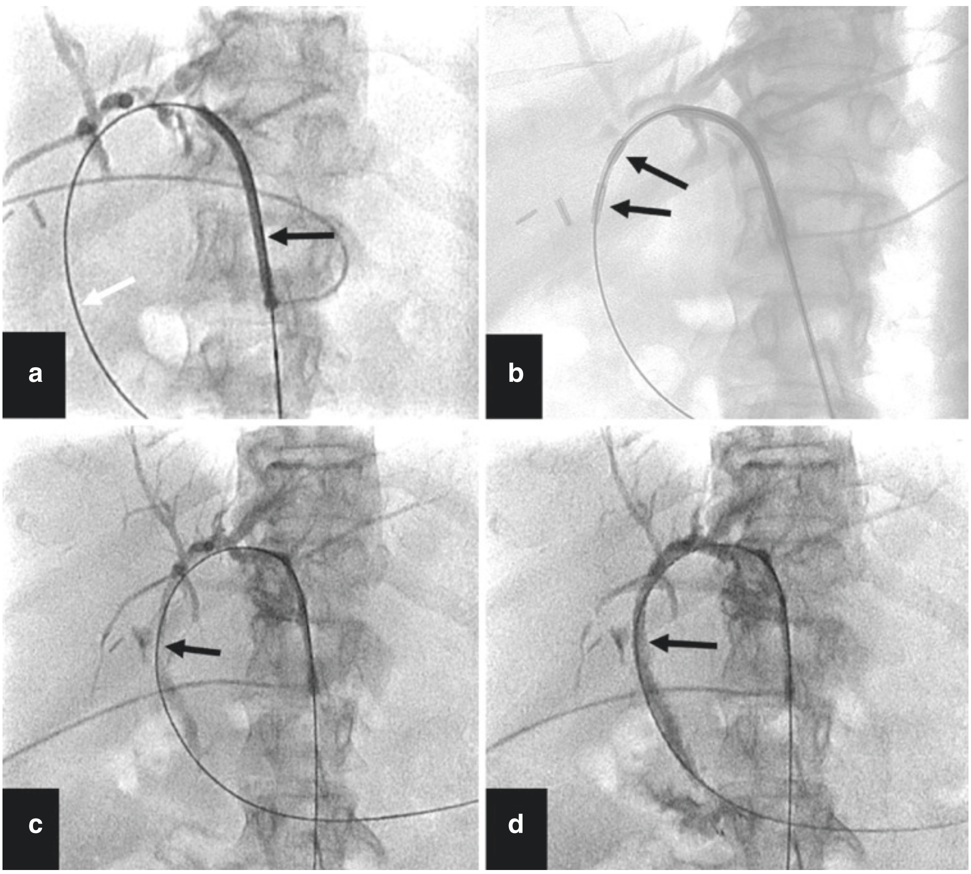

Fig. 2.22 Biliary radiofrequency ablation (RFA). (**a**) Cholangiogram obtained by a sheath (black arrow) placed over a wire (white arrow) shows obstruction of common hepatic duct. (**b**) Positioning of the RFA probe (arrows) over the wire at the site of tumor. (**c**) Cholangiogram after RFA shows flow of contrast across the stricture (arrow). (**d**) Placement of biliary stent after RFA (arrow). (Images courtesy: Dr. Amar Mukund, Additional Professor, Institute of Liver and Biliary Sciences, New Delhi)

rent cholangitis [30]. Uncommonly, they may present with jaundice or pain abdomen. Occasionally, the patients may be asymptomatic and liver function tests show abnormally elevated alkaline phosphatase. Chronic obstruction may result in secondary biliary cirrhosis and patient may present with features of portal hypertension like hematemesis or ascites.

2.7.2 Indications

Two most common indications are stricture of a bilio-enteric anastomosis (commonly hepaticojejunostomy) and post-liver transplant biliary stricture (Figs. 2.23 and 2.24). Other indications include CBD stones (Fig. 2.25), chronic pancreatitis, and infective/inflammatory strictures (recurrent pyogenic cholangitis, Immunoglobulin G4 cholangitis, ischemic cholangitis), when EBD is difficult or failed.

2.7.3 Special Considerations for PTBD

The steps of the PTBD procedure is similar to that described previously for malignant biliary obstruction. However, there are some special considerations. In obstruction due to benign strictures, the lesion gradually narrows the lumen and hence the dilatation of IHBD is mild in majority of cases. Hence, the absence of adequate dilatation should not be a reason to not do PTBD. Accordingly, the hardware for puncturing mildly dilated ducts are required (Fig. 2.2). For the same reason, the serum bilirubin is not much elevated and the patient is often not icteric. Elevation of serum alkaline phosphatase is a more consistent feature. Further, due to slow progression and recurrent episodes of cholangitis, the walls of bile ducts are frequently thick with periductal fibrosis. Hence, small caliber catheters, particularly 4F catheter, is useful to gain access into the system after the initial puncture. Crossing the obstruction is tougher than in malignant cases. The obstruction is mostly a fibrotic stricture and penetrating in with a wire is difficult compared to a softer tumor. The flow of contrast across the stricture to opacify the distal segments during the initial cholangiogram is a positive sign. The catheters which are inserted have to be in place for long duration to allow the stricture to remain patent after the catheter's removal. Catheter maintenance is often challenging in such conditions.

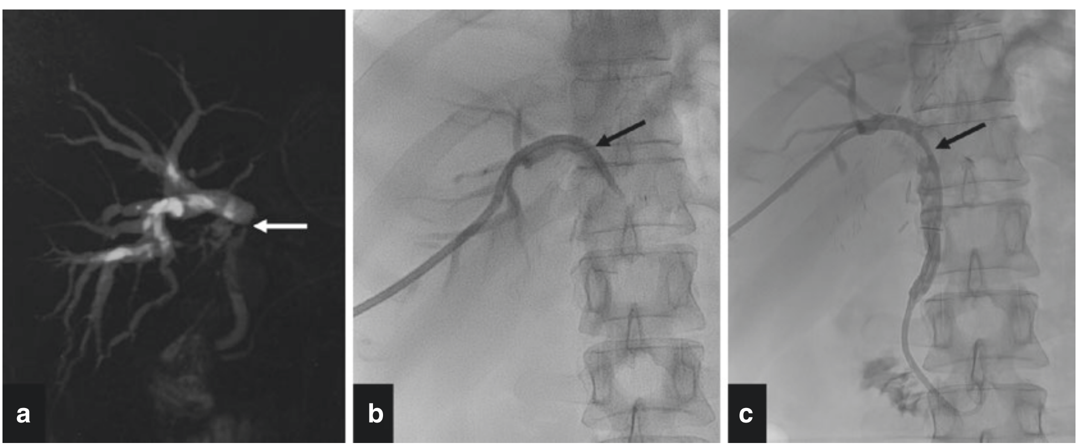

Fig. 2.23 Post-liver transplantation biliary stricture. (**a**) MRCP image shows tight anastomotic bile duct stricture (arrow) in a case of right lobe living donor liver transplantation. Endoscopic drainage failed. (**b**) Right PTBD with external drainage. (**c**) Ring biliary catheter (arrow) placement across the stricture after balloon dilatation

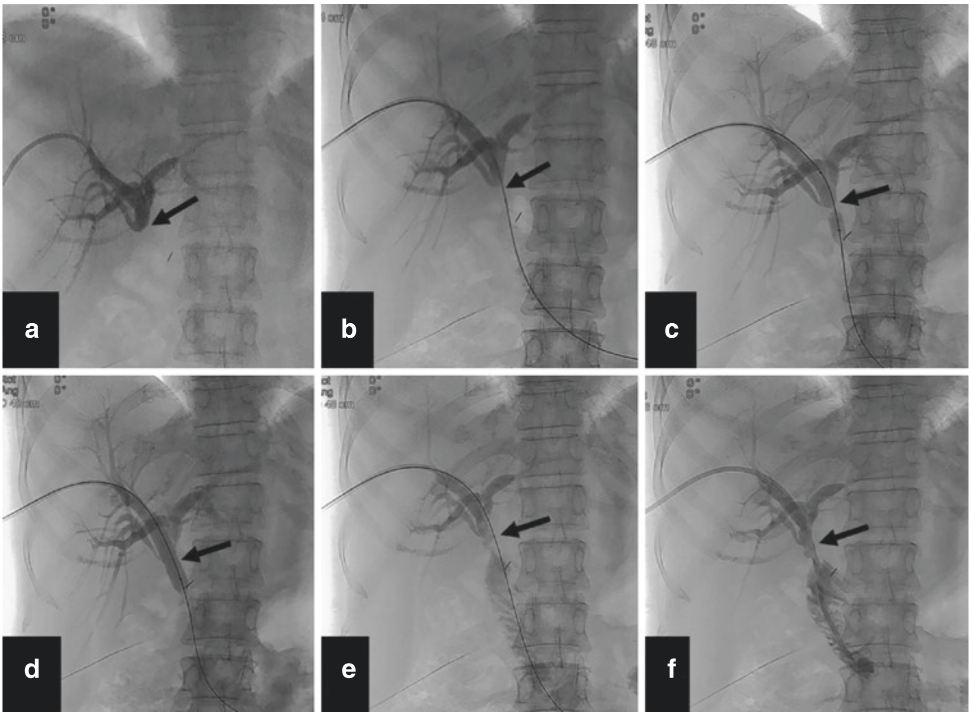

Fig. 2.24 Benign biliary stricture. (**a**) Initial cholangiogram shows complete stricture at the bilio-enteric anastomotic site (arrow). (**b**) Passage of guidewire across the stricture (arrow). (**c**) Dilatation using balloon catheter (10 × 40 mm) shows waist at the site of stricture (arrow). (**d**) Fully inflated balloon (arrow). (**e**) Cholangiogram after balloon dilatation shows free flow of contrast into the jejunum. (**f**) Final placement of 8.3F ring biliary catheter (arrow) across the stricture

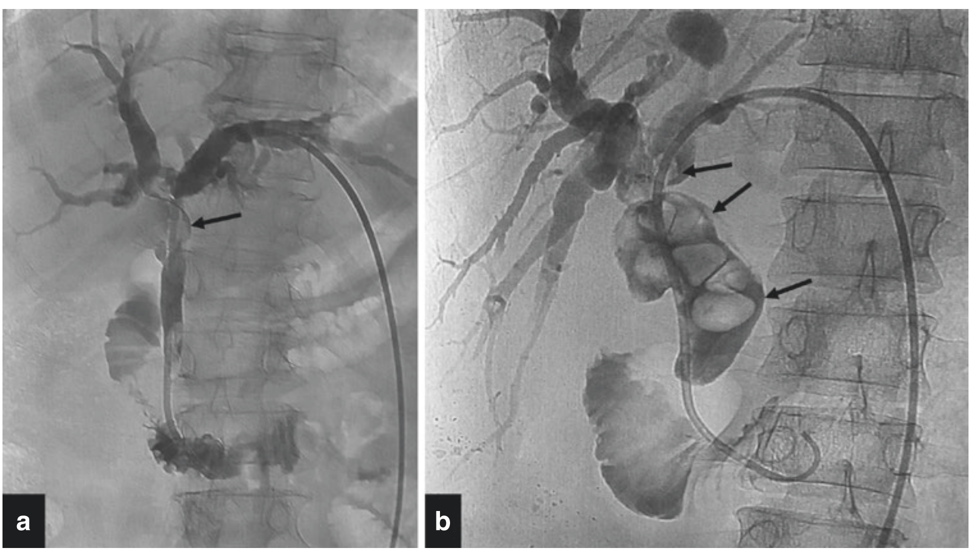

Fig. 2.25 PTBD for stone disease. (**a**) Left PTBD in a case of Mirrizzi's syndrome caused by a calculus seen as a filling defect (arrow) in the neck of gallbladder. (**b**) Left PTBD in a case of choledocholithiasis (arrows) with choledochal cyst. PTBD was done in both patients as endoscopic drainage was not possible due to associated cardiac comorbidities

2.7.4 Modifications

There are a few modified steps which are necessary or may be performed with PTBD when it is done for benign strictures.

Balloon dilatation (cholangioplasty) of the strictures is an important step to open up the strictures (Figs. 2.23 and 2.24). Once the stricture is crossed with a soft guidewire, it is exchanged for a stiff guidewire. Then, a vascular sheath (6F) is placed into the biliary system over the wire. Through the sheath, a balloon catheter, 8 or 10 mm (15–20% oversized compared to the size of the duct), is inserted [31]. With the markers of the balloon positioned appropriately, the balloon is dilated with an inflation device and kept for 3–5 min. A waist is usually seen, which has to be fully dilated. After this, the balloon is deflated and inflated again, to check for waist formation. Usually, after full inflation, waist is not seen on repeat dilatation of the balloon. Later, the balloon catheter is removed along with the sheath and an 8–10F ring biliary catheter is placed. For short segment strictures, short term and long-term patency rates for balloon dilatation are 90% and 74%, respectively [1, 32]. Lower patency is seen when the strictures are long segment and multiple.

Serial upgradation of catheters is a better option for the successful treatment of benign biliary strictures (Fig. 2.26) [33]. Even though the stricture is dilated with a 10 mm balloon catheter, it gradually heals and remodels around the catheter which is inserted. Once a smaller caliber ring biliary catheter (usually 8F) is placed, it is upgraded in a staged manner, every 4 weeks, to 10F, 12F, and then to 16 or 18F. Once the final size is reached, it should be kept for 3–6 months to allow the stricture to completely heal around the catheter and maintain patent [33]. After the end of the treatment, patency of the stricture may be evaluated by a cholangiogram using a vascular sheath, after removal of the catheter over a wire. Prompt distal flow of contrast across the stricture and absence or little proximal stasis suggest successful treatment. This protocol has good long-term results, with failure or recurrence rates in the range of 12–44% [34, 35].

Cutting balloon and high-pressure balloon catheters have also been used in the dilatation of hard fibrotic strictures with reasonable success rates [36, 37]. Cutting balloon catheter, as the name indicates, has thin metallic blades on the surface of the balloon, which creates cuts in the fibrotic wall and opens up the stricture on the dilatation of the balloon. Similarly, high-pressure balloon catheters endure high inflation pressure without bursting of the balloon. Hence, they are useful in the opening up of tight strictures.

Stents have also been used in the management of benign biliary strictures [38, 39]. Although it is not usually advisable, in chronic and inoperable cases, this may be the only practical option. Typically, retrievable or spontaneously migrating covered stents are preferred, although it is technically challenging to remove them. Non-retrievable stents usually get occluded by sludge and debris in 8–12 months. Compared to balloon dilatation, the stent placement has higher 3-year patency rates (53% versus 85%) [39]. Currently, there is ongoing research on the use of biodegradable stents for benign biliary strictures and it has shown promising results, with a stricture recurrence rate of about 30% at 3 years [40].

Stone removal should be attempted when there are calculi obstructing the biliary system or when there are secondary calculi proximal to a benign stricture (Fig. 2.27) [41, 42]. It is important to remember that only handful of stones may be successfully removed by percutaneous interventions. If there are too many calculi, surgery is the better option after PTBD for their removal. Removal of the stones is done with the use of a balloon catheter (6–10 mm). Since most are secondary calculi, majority of them are not calcified and are soft stones which could be macerated by balloon catheters. Access of the biliary system should be planned carefully as it should be proximal to the site of the location of the stones [1, 5]. Cholangiogram will confirm the location and number of filling defects. After insertion of a stiff guidewire across the obstruction and a vascular sheath proximally, the balloon catheter (preferably compliant) is inserted to reach proximal to the calculi. Then it is partially inflated and pushed over the wire to push the calculi into the duode-

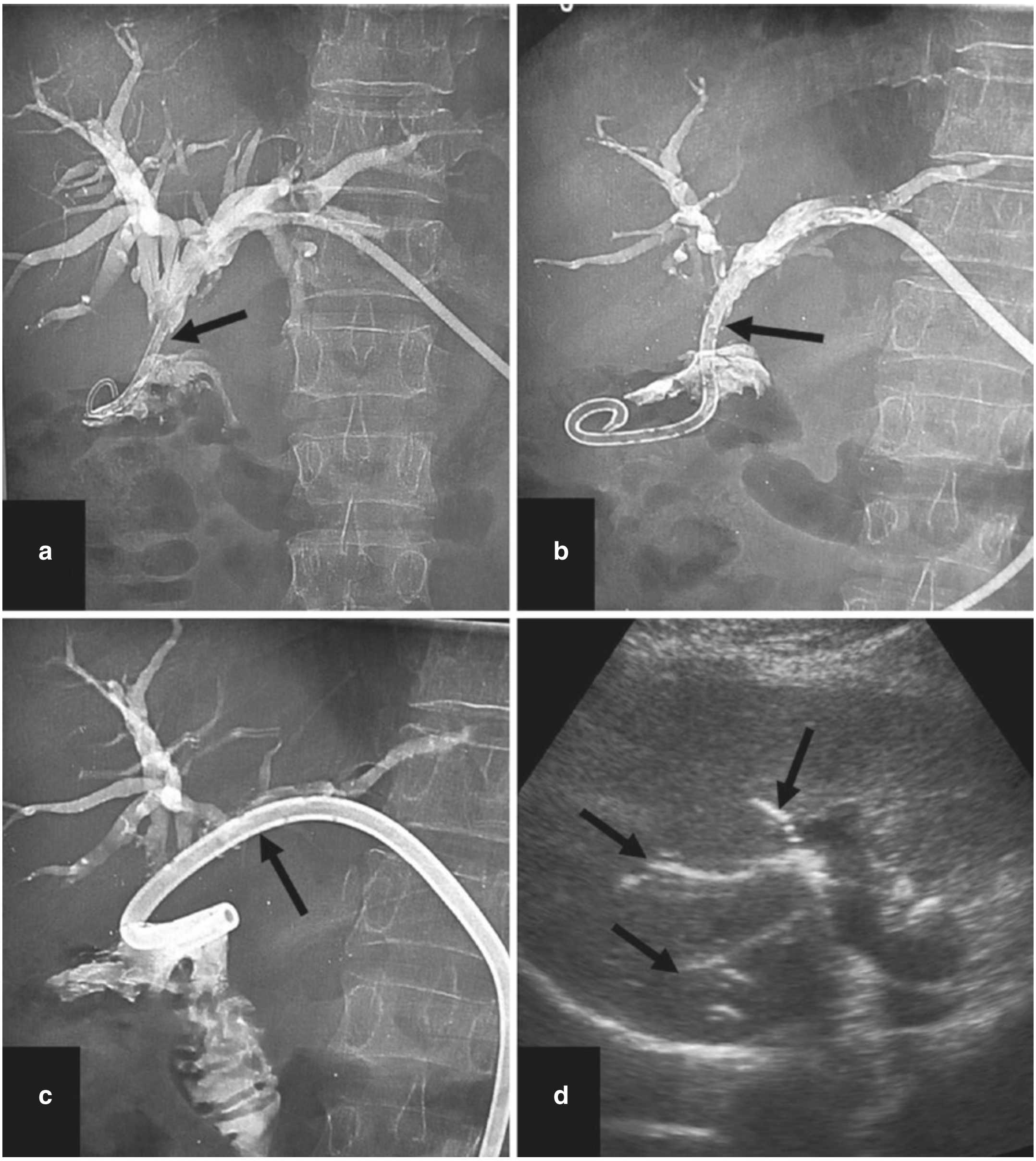

Fig. 2.26 Serial upgradation of catheter. (**a**) 10F ring biliary catheter (arrow) across the bilio-enteric anastomotic stricture after 4 weeks of placement of 8.3F catheter. (**b**) 12F catheter (arrow) placed after 4 weeks. (**c**) 16F catheter (arrow) placed after another 4 weeks. This catheter is placed for a minimum of 3 months. (**d**) Ultrasonography after 3 months of removal of 16F catheter shows pneumobilia (arrows) suggesting patency of the anastomosis

num or bowel loops (Fig. 2.27c, d). Multiple such attempts may be necessary to clear larger or multiple calculi. However, impacted stones may pose a bigger challenge and may require a cholangioscope to fragment them with holmium laser. Success rates of percutaneous stone extraction are about 90% for common bile duct calculi and 60% for intrahepatic bile duct stones [43].

Duct localization is an important procedure performed for benign biliary strictures involving the hepatic hilum. Hilar strictures, mostly after a cholecystectomy, pose a problem for the surgeon,

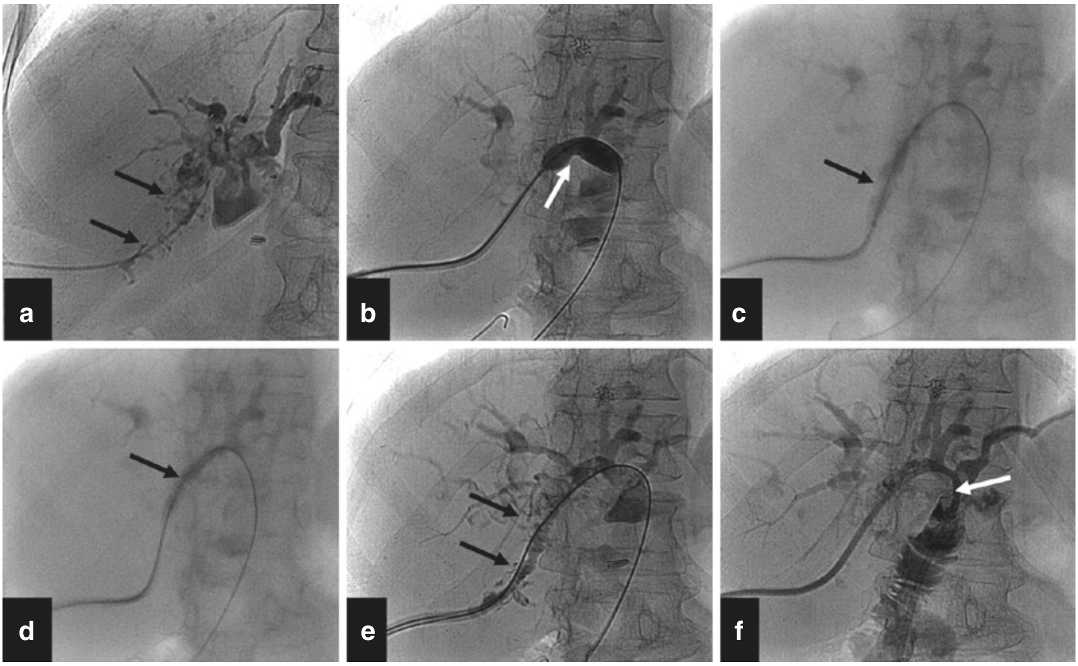

Fig. 2.27 Stone extraction in a case of bilio-enteric anastomotic stricture. (**a**) Initial cholangiogram shows multiple filling defects (arrow) within the bile ducts suggestive of calculi. (**b**) Balloon dilatation of the anastomotic stricture using balloon catheter (10 × 40 mm). (**c**, **d**) Pushing of the calculi into the jejunum by sweeping the partially distended balloon catheter over the wire from the bile ducts into the duodenum (arrow). (**e**) Post multiple balloon sweeps, cholangiogram shows reduction in the intrabiliary filling defects (arrows). The residual calculi were removed in the second session. (**f**) Placement of ring biliary catheter across the anastomotic stricture (arrow)

as they are frequently difficult to identify due to extensive surrounding adhesions and fibrosis. Hence, prior to a definitive bilio-enteric anastomotic surgery, PTBD (unilateral or bilateral, often the latter) is done with catheters placed just proximal to the stricture (Fig. 2.28). This helps the surgeon as he can palpate the catheter at surgery and thus identify the ducts. The procedure is similar to any PTBD.

2.8 PTBD for Bile Leaks

Bile leak occurs as a complication of many biliary procedures, commonly, cholecystectomy, pancreatic surgery, hepaticojejunostomy, and hepatectomies, with an incidence ranging from 0.5% to 20% depending on the type of surgery [44, 45]. Leak may occur either due to bile duct injury or anastomotic site leak. Bile leak leads to formation of collections (bilomas) which may get infected. Also, constant leak of bile from the surgical site prevents internal healing. Although endoscopic drainage is the initial option, in cases where there is complete separation of proximal and distal ends (which leads to difficult cannulation of proximal segments), bile duct ligation, altered anatomy (hepaticojejunostomy) or disruption of an aberrant duct, EBD may not be possible or successful [46]. PTBD in such cases is the treatment of choice. It helps in diverting the bile to an external collector bag and thus allows healing of the surgical site internally. However, imaging with USG, CT scan, MRI, and/or cholescintigraphy should be done to look for collections, duct caliber, and level of bile leak prior to performing PTBD.

2.8.1 Indications

Any hepatobiliary or pancreatic surgery with suspected or confirmed bile leak, when EBD is not possible or contraindicated.

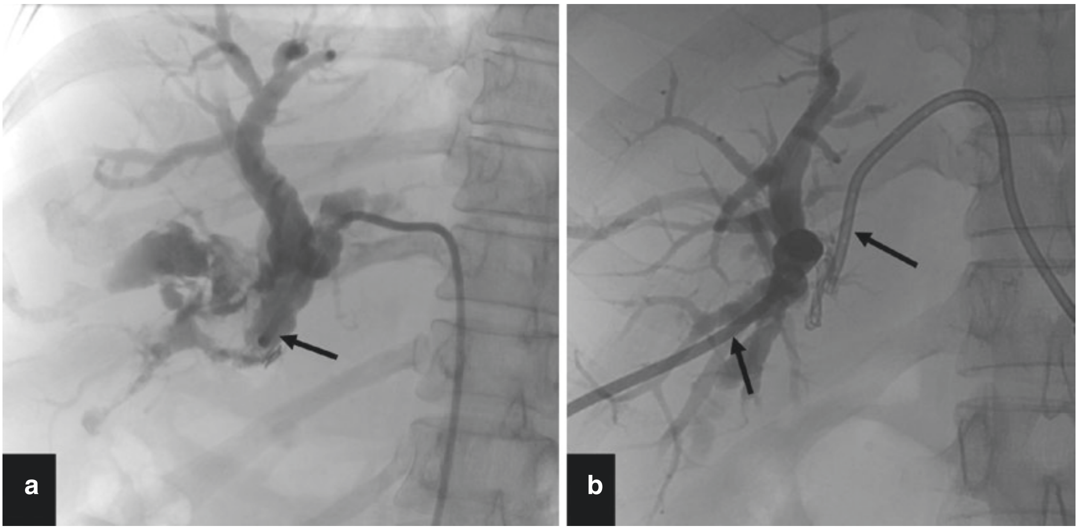

Fig. 2.28 Preoperative PTBD for duct localization in benign biliary strictures. (**a**) Left PTBD with external drainage catheter (arrow) in a case of benign biliary stricture with patent primary confluence. (**b**) Bilateral PTBD with external drainage catheters in a case of benign biliary stricture involving hepatic hilum

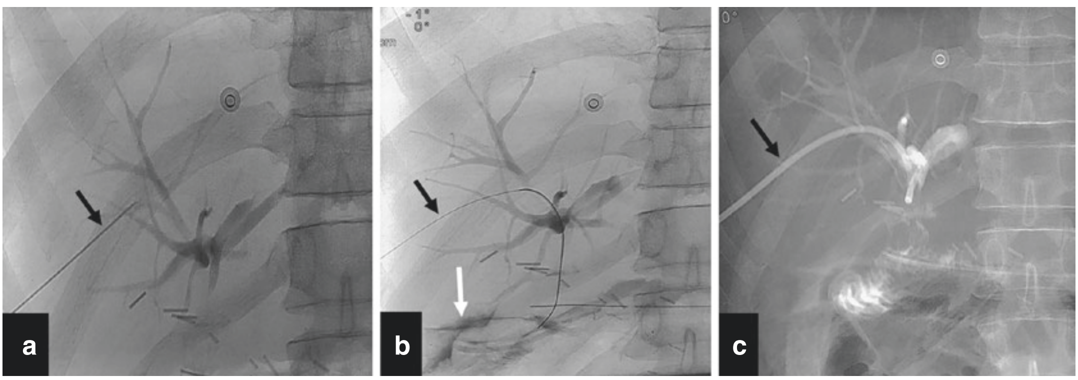

Fig. 2.29 PTBD for bile leak from bilio-enteric anastomosis. (**a**) Cholangiogram using 22G Chiba needle shows opacified bile ducts. (**b**) Guidewire (0.018 inch; black arrow) is passed into the duodenum through the anastomosis. Contrast leak (white arrow) is also seen. (**c**) Final placement of 8F pigtail catheter (arrow), proximal to the anastomotic site

2.8.2 Procedure

The patient should be prepared with broad-spectrum antibiotics, to reduce the risk of cholangitis and sepsis.

The most critical step of the procedure of PTBD done for bile leaks is the initial puncture of the ducts. Since there is bile leak, there is hardly any dilatation of the IHBD. In fact, the ducts are decompressed due to leak. Hence, USG guided puncture is mostly difficult. Fluoroscopy guidance along with USG is the preferred choice, usually from the right side.

The skin site chosen should be below the tenth intercostal space, in the mid axillary line, to avoid puncturing the pleura (Fig. 2.29) [47]. Further, central puncture of the ducts should be avoided. The puncture needle (22G, 15 cm) should be guided cranially by about 20^0 and anteriorly by about 20^0, and inserted for about

5–7 cm. The direction may be adjusted using USG as guidance to target the portal tract (bile ducts run parallel to the portal vein radicles). Then, contrast is injected slowly while withdrawing the needle. Once the biliary system is opacified, a wire (0.018 inch) is passed into the ducts (Fig. 2.29b). Subsequently, standard steps are followed. In most cases, an 8F pigtail catheter is placed for external drainage, with its tip proximal to the site of leak, so as to reduce the amount of bile reaching the site of leak (Fig. 2.29c). Internalization should be attempted in patients without signs of infection [48]. This gradually heals the surgical site, usually with the formation of fibrosis and often stricture. Similarly, the left duct may be punctured with a combination of USG and fluoroscopy, whenever the right duct puncture is difficult due to the small right lobe or large adjacent biloma (Fig. 2.30). Frequently, the drainage of biloma is also necessary.

The technical success of performing a PTBD for bile leak is in the range of 40–100% [49]. The complications are similar to that of PTBD done for malignant obstruction, but have a higher incidence due to non-dilated ducts [50].

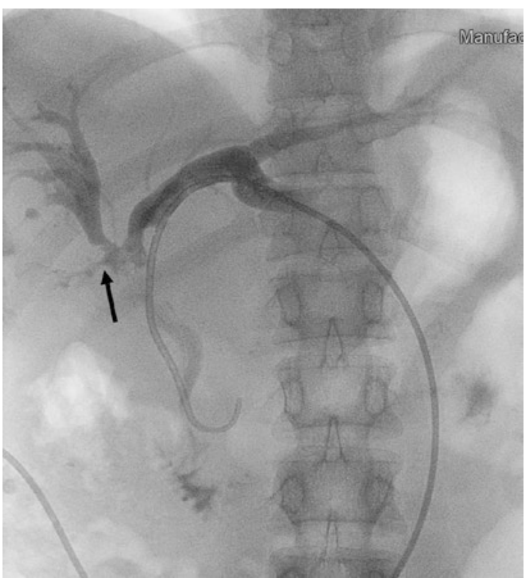

Fig. 2.30 PTBD for bile leak. Left PTBD with internal–external drainage catheter in a patient of post cholecystectomy bile leak from common hepatic duct (arrow)

2.9 Percutaneous Cholecystostomy

This is a technique where the gallbladder is drained percutaneously under USG guidance with the help of a catheter. This assists in decompressing an obstructed gallbladder or indirectly the biliary system.

2.9.1 Indications

The common indications include acute cholecystitis with impacted stone in the neck, empyema of the gallbladder, and bile duct obstruction (malignant or benign) with non-dilated IHBD, especially in patients who are poor candidates for surgery or EBD [51, 52]. It is also indicated in patients with malignant biliary obstruction when transhepatic biliary drainage is not possible due to multiple metastases or other diffuse liver diseases.

2.9.2 Procedure

The procedure is usually done under USG guidance or uncommonly under CT guidance, using the standard trocar or Seldinger technique performed for collection drainage [53]. The aim is to place a catheter into the distended gallbladder. It is performed usually under local anesthesia and mild sedation.

There are two approaches described in the literature. They are transhepatic route and transperitoneal route [54]. Both routes have their advantages and disadvantages. In transhepatic route, the needle path traverses some part of liver parenchyma before entering the gallbladder (Figs. 2.31 and 2.32). In transperitoneal route, the catheter enters the gallbladder directly from the abdominal wall, without liver intervening. The former approach is associated with reduced risk of bile leak, lesser chances of catheter dislodgement and earlier maturation of the tract, but higher risk of bleeding complications and fistula formation whereas the latter approach has higher incidence of biliary peritonitis [53, 55, 56]. However, a recent study has shown that there is no significant difference between the two approaches in terms of complications [54]. The choice, thus, depends on the IR specialist and the patient factors like body habitus, intervening bowel loops, size of the gallbladder, and the thickness of the liver segment. It is important to note that there is a high chance of catheter dislodgement after cholecystostomy once the gallbladder decompresses after drainage. It is thus suggested that the puncture is made close to the region of the fundus of the gallbladder with sufficient length of the catheter pushed towards the neck region to reduce the chances of catheter displacement. Once cholecystostomy is done, the catheter should preferably be left in place for at least 2 weeks. This will lead to the formation of tract around the catheter and thus avoids any complications due to bile leak. After catheter removal, the tract will eventually close, provided the normal drainage path of the gallbladder is patent.

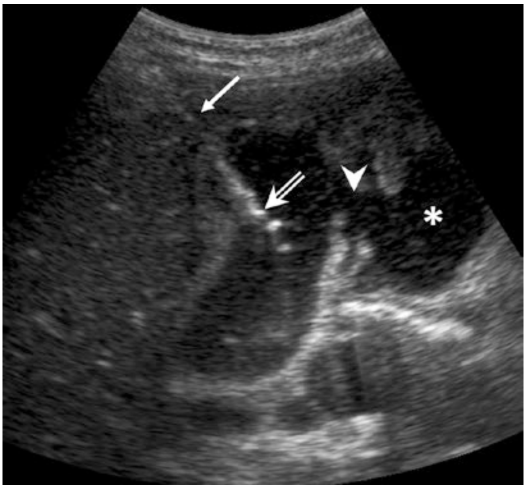

Fig. 2.31 Cholecystostomy. Ultrasonography guided percutaneous cholecystostomy (open arrow) through transhepatic route (arrow) in a case of complicated cholecystitis with perforation (arrow head) and pericholecystic collection (asterisk)

2.9.3 Complications [56]

Bile leak—it is one of the important complications of percutaneous cholecystostomy. It is more common when a transperitoneal approach is used. There may be bile leak around the catheter or through partial displaced catheter into the peritoneal cavity. This leads to biliary peritonitis and biloma formation. It is best to try and prevent such complications. The removal of catheter should be avoided before 2 weeks. Few studies suggest doing a cholecystogram before removal of the catheter to check for any leaks (Fig. 2.32c). Biloma, once formed, should be drained with a pigtail catheter.

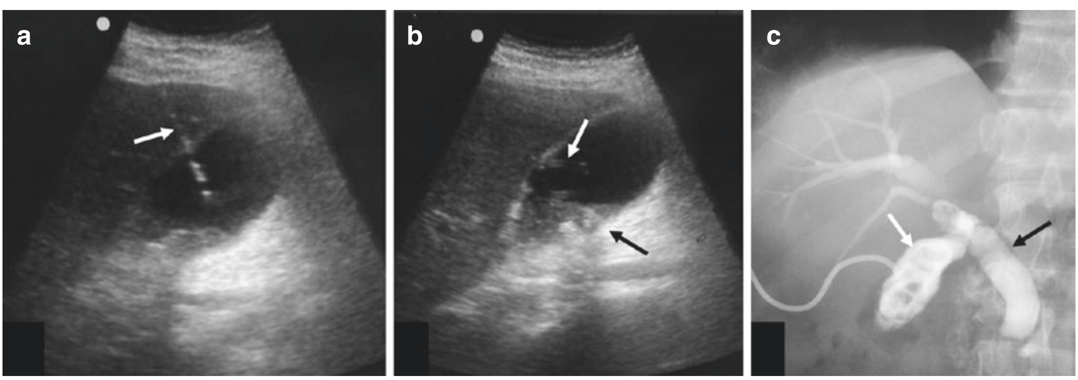

Fig. 2.32 Percutaneous cholecystostomy in a case of gallbladder empyema with gall stones. (**a**) USG guided transhepatic cholecystostomy (arrow). (**b**) USG image shows pigtail catheter in the lumen of gallbladder (white arrow) with calculi and sludge (black arrow). (**c**) Cholecystogram shows multiple calculi in the gallbladder (white arrow) as filling defects with dilated common bile duct (black arrow). This route can be used to perform biliary interventions

Hemorrhage—it is mostly self-limiting. In cases of persistent hemorrhagic fluid draining from the catheter, CT angiogram should be done to look for the cause of bleeding. If any arterial source is found, e.g., cystic artery or hepatic artery pseudoaneurysm, DSA and embolization should be done.

Catheter dislodgement—this is a common complication. Adequate care must be taken to ensure insertion of a good length of the catheter into the gallbladder lumen, optimal fixing the catheter and its maintenance. Locking pigtail catheter should be placed, if possible. If the catheter is partially displaced, it should be repositioned. If repositioning fails or if the catheter is completely dislodged, performing a repeat procedure may be difficult as the gallbladder will be completely collapsed. Depending on the need for a repeat cholecystostomy, the patient may be kept under observation until gallbladder distends sufficiently or the patient does not respond to treatment.

Pericatheter leak and *low or absent drain output* may suggest occlusion of the catheter with debris and sludge and need replacement of the catheter, with a larger size.

Other complications, like cholangitis, skin infection, and abscess, require treatment with antibiotics. Local pain is managed by analgesics.

2.9.4 Transcholecystic Interventions

Percutaneous cholecystostomy may be used as an access route for performing some biliary interventions [57, 58]. This is done in benign as well as malignant biliary obstructions. The procedures done include placement of internal drainage catheters, stent placement, and stone extraction. These are done under fluoroscopy guidance.

The procedures should be performed after maturation of the tract which takes 2–3 weeks. The drainage catheter is exchanged for a sheath (6–8F) over a wire. Then with the use of an angled catheter and hydrophilic guidewire, the cystic duct is crossed and the bile duct is entered. Then, the obstruction is crossed with the same wire and catheter to enter the duodenum. Subsequently, a stiff guidewire is placed to replace the hydrophilic soft wire. This can then be used to perform various interventions. A ring biliary catheter or SEMS may be placed as indicated, for internal drainage. Removal of bile duct stones may also be attempted with the help of a balloon catheter. The tract may be widened from 20F to 26F for removal of gall stones in patients who are not fit for surgery due to comorbid conditions. Tortuous cystic duct may pose a problem sometimes, especially if the obstruction is mild. Major complications like hemorrhage, bile leak, and pneumothorax are uncommon, seen in <5% patients [56].

2.10 Conclusion

Biliary interventions are important non-vascular interventional procedures which should be learned by every IR specialist. Being well versed with the basic steps of the commonly performed biliary interventions described here is critical for a successful procedure with minimal complications. Knowledge of the complications will help in their appropriate evaluation and treatment, when necessary. The protocol for managing benign biliary strictures percutaneously is evolving; long-term placement of larger catheters seems to be the feasible option. Further research in this aspect is ongoing and their results may help optimize the protocol.

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