Biliary Interventions: Tools and Techniques of the Trade, Access, Cholangiography, Biopsy, Cholangioscopy, Cholangioplasty, Stenting, Stone Extraction, and Brachytherapy

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Semin Intervent Radiol 2016;33:283–290

Abstract

Keywords

- ▶ biliary interventions
- ▶ cholangiography
- ▶ cholangioplasty
- ▶ biliary stenting
- ▶ interventional radiology

Therapeutic access to the biliary system is generally limited to endoscopic or percutaneous approaches. A variety of percutaneous transhepatic biliary interventions are applicable for the diagnosis and treatment of biliary system pathologies, the majority of which may be performed in conjunction with one another. The backbone of nearly all of these interventions is percutaneous transhepatic cholangiography for opacification of the biliary tree, after which any number of therapeutic or diagnostic modalities may be pursued. We describe an overview of the instrumentation and technical approaches for several fundamental interventional procedures, including percutaneous transhepatic cholangiography and internal/external biliary drainage, endobiliary biopsy techniques, cholangioscopy, cholangioplasty and biliary stenting, biliary stone extraction, and intraluminal brachytherapy.

Objectives: Upon completion of this article, the reader will be able to describe the indications, instruments, and procedural techniques of the fundamental interventions of the biliary system.

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A variety of transhepatic percutaneous biliary interventions are applicable for the diagnosis and treatment of biliary

system pathologies. We describe an overview of the instrumentation and technical approaches for several fundamental interventional procedures, including percutaneous transhepatic cholangiography (PTC) and internal/external biliary drainage, endobiliary biopsy techniques, cholangioscopy, cholangioplasty and biliary stenting, biliary stone extraction, and intraluminal brachytherapy.

Percutaneous Transhepatic Cholangiography and Internal/External Biliary Drainage

Percutaneous transhepatic biliary drainage (PTBD) is an image-guided therapeutic procedure involving bile duct cannulation, followed by internal/external catheter drainage of bile contents. Drainage is performed subsequent to needle-directed contrast opacification of the biliary tree via PTC. PTBD is indicated for decompression of the biliary tree, most commonly in malignant obstruction, and is usually reserved

for when endoscopic intervention fails or if there is high intrahepatic obstruction.¹

Preprocedure Considerations

Initial consult should always include a focused history and exam, and informed consent should be obtained. Pertinent laboratory exams include complete blood cell count, liver function tests (LFTs), coagulation factors, platelets, and serum bilirubin. Ascites and coagulopathy are relative contraindications that should be corrected prior to intervention.² Prior imaging including magnetic resonance cholangiopancreatography or computed tomography (CT) should be carefully studied for identification of biliary obstruction and planning of needle approach.

Routine intravenous (IV) access is established and normal saline is given to prevent dehydration. Moderate sedation with IV fentanyl and midazolam can be used in patients naive to narcotic medications; alternatively, deep sedation or general anesthesia may be required or used per patient and/or institutional preference. Local anesthesia with 2% lidocaine is used for the puncture site. Antibiotic prophylaxis is given as the obstructed biliary system is considered contaminated. Preferred agents to prevent biliary sepsis include 1.5 to 3 g IV ampicillin/sulbactam, 1 g IV ceftriaxone, or piperacillin/tazobactam.³ For penicillin-allergic patients, vancomycin or clindamycin with an aminoglycoside can be given.

General Procedure Technique

The patient should be positioned supine in the field under sterile drape and prep. Right- or left-sided approach is based on surgeon's preference and site of obstruction. While left-sided approach is more comfortable for the patient and has essentially no risk of pulmonary complications, it is also associated with more radiation exposure and a more acute angle in the common duct that is difficult to manipulate.^{1,2} Additionally, both ultrasound and fluoroscopic-guided approaches can be used. We describe a right-sided, fluoroscopic-guided approach.

Under fluoroscopy, the patient fully inspires, and the puncture site is chosen in the midaxillary line, just caudal to the costophrenic angle. A 21G needle is inserted cephalad toward the thoracic spine near T12 during mid inspiration. There is a risk of pneumothorax, increased with a right-sided approach. The inner stylet is withdrawn, and then the needle is withdrawn while injecting contrast until a bile duct is visualized.² Contrast will move away from the hilum in the vasculature and will appear small and beaded in the lymphatics, but when the bile duct is entered, it will move slowly toward the hilum. If no duct is entered on withdrawal, the needle can be reinserted several more times to retry. Once a duct is entered, care should be taken during injection not to overdistend, as this can lead to sepsis. If the duct is dilated, decompression by aspiration before cholangiogram is necessary.¹ With right-sided approach, patient may need to roll left to better visualize the more anterior portal system of the left lobe.

Once the duct is entered and presents a suitable angle for access, a 0.018-in. platinum tip guidewire is inserted through

the needle into the collecting system, common duct, and into the small bowel if possible.² Occasionally, if the angle of entry is too high, it may be necessary to perform a second stick with another needle into a lower (preferable segment 6) biliary duct. Once the 0.018-in. guidewire is advanced into the bowel, the needle is then removed. And then 3 and 5F or 4 and 6F coaxial sheaths can be advanced over the guidewire; the wire and the smaller, internal French sheath are then removed, allowing the introduction of a 0.035-in. guidewire into the larger diameter outer sheath. This combination can now be used to traverse strictures and manipulate into the small bowel. If this is not possible, external drainage for decompression with an 8F biliary drainage catheter can be used for a few days, after which manipulation into the bowel will be retried.¹ If the wire can be placed into the bowel, serial dilation can be pursued with 7 and 9F catheters, with ultimate placement of an internal/external 8F or 10F biliary drainage catheter (→Fig. 1). Ensuring the side holes are in the bile duct and above the obstruction is essential, as side holes in the liver parenchyma can lead to hemobilia.¹ This can be verified by injecting a small amount of contrast. A distal loop formed in the duodenum ensures internal fixation, and 2.0 Prolene or silk can be used to suture the external portion to the skin.

Postprocedure

The catheter should be left to external drainage and output color and content should be monitored, after which the external catheter can be capped following normalization of bilirubin. In the setting of cholangitis, the catheter should remain to gravity drainage for a longer period of time until the acute infection resolves. The catheter should be flushed daily with 5 to 10 mL normal saline. Postoperative complications include cholangitis and pancreatitis; note that 10F catheters are associated with a lesser risk of cholangitis.⁴ External catheter should be uncapped in this setting and the source of the fever and pain should be investigated.

Endobiliary Biopsy Techniques

Percutaneous transhepatic endobiliary biopsy may be performed with varying techniques that include exfoliative cytology of bile aspirates, intraluminal brush biopsy, and intraluminal forceps biopsy. They are generally reserved when endoscopic access is unsuccessful or not feasible. Procedures are done under fluoroscopic guidance during PTBD or with direct visualization during PTCs. Although ultrasound-guided fine needle aspiration biopsy is generally used for histopathologic diagnosis of the majority of tumors, this method is significantly less sensitive for small biliary tumors.^{5,6} Endobiliary biopsy techniques are more successful in establishing a diagnosis of malignancy. Forceps biopsy has the highest sensitivity, followed by brush cytology and bile aspiration, although combined brush cytology with biopsy is more effective in the diagnosis of malignant strictures.^{5,7-9}

Preprocedure Considerations

Preprocedure considerations are the same as those for PTC.

Fig. 1 Percutaneous transhepatic biliary drainage. (a) Initial spot radiograph of the abdomen with hemostat (arrow) overlying the subcutaneous tissues delineating the puncture trajectory. (b) Contrast injection demonstrates percutaneous access into a segment 5 biliary duct (arrow). (c) Utilizing a “two-stick” method, a segment 6 duct is percutaneously accessed and a 0.018-in. guidewire is advanced into the duodenum (arrow). Using this access, an internal/external biliary can be placed after serial upsizing and dilation. (d) Using this access, an internal/external biliary catheter (arrow) can be placed after serial upsizing and dilation.

General Procedure Technique

The procedure begins with PTC and biliary drainage.

Exfoliative cytology of bile aspirates may be performed simultaneously by collecting 10 to 15 mL of bile during biliary decompression.⁷ This method is usually performed in conjunction with other techniques as the cytologic yield is often inadequate and the test has poor sensitivity.^{7,9} Repeated brushings followed by biliary lavage fluid collection is a significantly more effective diagnostic technique.^{9,10}

Brush cytology of suspicious strictures improves cytologic yield. Cytology brushes are generally 3 mm in diameter, 2.5 to 5 cm in length, and have angled bristles with a possible flexible tip that are completely retractable into a 6 to 8F sheath.^{9,11} The brush and catheter combination is inserted

over a 0.035-in. stiff guidewire and positioned near the stricture or lesion of interest. The brush is deployed through the sheath and across the stricture for repeated scrapings of the biliary mucosa, before being fully retracted into the catheter sheath and removed.⁹ The brush is opened and smeared against one or more glass slides and the tip is cut and placed in a bottle with fixative and sent to pathology for microscopic examination of cytology, molecular markers, and DNA analysis.⁹

Forceps biopsy under fluoroscopy may be performed during percutaneous biliary drainage. An 8F catheter sheath is advanced near the stricture over a 0.035-in. stiff guidewire; the inner dilator is removed and a small diameter forceps is inserted and advanced to the stricture.^{5,7} Several samples

may be taken and used for histopathologic analysis as an adjunct to brush cytology.⁹ Forceps biopsy is superior for detecting cholangiocarcinoma when compared with deeper malignancies of the biliary system, as biopsy is limited to the superficial biliary mucosa.^{5,7,12} Furthermore, identification of tumor vessels by cholangioscopy is suggestive of malignant extension that will be difficult to assess by superficial biopsy methods.^{12–14}

Postprocedure

A similar postprocedure protocol with respect to PTBD should be utilized depending on the method of access.

Cholangioscopy

Percutaneous transhepatic cholangioscopy (PTCS) is a direct imaging method to visualize the biliary system for diagnostic and/or therapeutic purposes. Diagnostic cholangioscopy can visualize and characterize strictures, and can be augmented with brush cytology or forceps biopsy to differentiate benign from malignant lesions. Assessment for the extent of distal malignant invasion and degree of required resection can also be performed.^{13,15} Therapeutic interventions of PTCS include electrohydraulic lithotripsy for intrahepatic or common bile duct stones, photodynamic or laser palliative therapy of malignancies, and other catheter-driven therapies.^{15,16} PTCS is generally reserved when endoscopic retrograde cholangiopancreatogram (ERCP) or peroral cholangioscopy is unsuccessful or not feasible. This is usually in a difficult-to-approach gastrointestinal anatomy such as Billroth II or Roux-en-Y gastrojejunostomy, inaccessible, intrahepatic or large biliary stones >1.5 cm, or other contraindications to the peroral route.¹⁷

Preprocedure Considerations

Preprocedure considerations are the same as those for PTC. Note that individual therapeutic procedures in conjunction with cholangioscopy have their own indications and contraindications.

PTCS requires a scope, light source, processor, irrigation pump, and separate lithotripsy generator if necessary.¹⁵ Cholangioscopes for percutaneous interventions are generally 4.8 to 6.0 mm in diameter and 35 to 70 mm in length, with a relatively wide, 2.0 to 2.6 mm accessory channel, through which additional therapeutic instruments can be passed, including lithotripsy fibers, baskets, forceps, balloon dilators, and guidewires.^{14,15} Percutaneous cholangioscopes commonly used are the Olympus CHF, Pentax FCN, and Pentax ECN; these reusable scopes contain tips with up-down deflection and provide a field of view up to 125 degrees. Densely packed optical fibers in the larger diameter percutaneous scopes also enhance image quality.¹⁵ Narrow band imaging (NBI) enhances visualization of the mucosal microvasculature and aids in early identification of dysplastic tissue, but is only available in peroral video-cholangioscopy. However, the Olympus CYF-VA2 cystoscope with NBI has been described in the use of percutaneous cholangioscopic lithotomy procedures.^{17,18} Scopes also contain a

three-way valve lock for saline irrigation through the working channel.

General Procedure Technique

The procedure begins with PTC and biliary drainage. Similar to other biliary interventions, the catheter insertion site should be chosen based on the location of stones, strictures, or other pathology previously identified after a careful review of imaging. Furthermore, maneuvers of the cholangioscope are more difficult than catheter maneuvers; therefore, access to the opposite lobe may prove unsuccessful, placing more significance on the chosen entry site.¹⁵ Percutaneous cholangioscopy should not be performed upon initial access to the biliary system. Serial dilation of the tract up to 18F is required with subsequent tract maturation, but the initial internal/external biliary drainage catheter should not exceed 10F. The catheter should be left to external drainage overnight, then capped for several days, after which the tract can be dilated in intervals. Complications during PBD and dilation include cholangitis and bacteremia; however, interval dilation significantly reduces PTCS-related mortality.^{19,20} Therefore, dilation should be performed in two sessions over 1 week, and should be followed by at least 1 additional week to allow adequate drainage and tract maturation.¹⁷ Complications during this period include catheter migration and blockage.²⁰ If same-day access is critical, an 18F peel away sheath or metal sheath can bridge the immature tract to prevent extravasation of the bile into the liver parenchyma or peritoneum.²¹

Once adequate drainage is obtained and a mature tract is established, the drainage catheter is removed over a 0.035-in. stiff guidewire. The cholangioscope's tip is lubricated and inserted over the guidewire under fluoroscopic and endoscopic guidance, followed by removal of the guidewire; if the cutaneobiliary tract has not matured, however, a second parallel wire can be inserted adjacent to the scope to maintain access.²¹ Cholangioscopy should be performed with a dual operator technique: one operator for the scope and one assistant handling therapeutic accessories and irrigation.^{15,21} Irrigation should be maintained in all subsequent interventions, but biliary pressure should ideally not exceed 30 cm H₂O to prevent bacteremia by cholangiovenous translocation.²² After insertion of the scope, the remainder of the procedure is dependent on the initial indication.

Strictures and obstructing masses should be examined for excessive nodularity, mucosal irregularity, and mucosal ulceration that suggest malignancy.^{23,24} Identification of aberrant neovascularization around suspicious strictures, dubbed "tumor vessels," may also predict a diagnosis of malignancy.^{13,14} Forceps are passed through the therapeutic channel for biopsy. If the scope's tip is angulated, the forceps will be difficult to advance; in this case, withdraw the scope first, advance the forceps through, then advance the scope firmly, thus flexing the biopsy forceps to allow sampling.^{21,25} Brush cytology should be performed in a similar manner. To advance beyond difficult strictures, initial cholangioplasty may be required.

Intraductal disintegration of biliary stones can be performed by electrohydraulic lithotripsy or laser lithotripsy,

with the latter becoming more popular due to a lesser risk of bile duct injury.²⁵ Both of these interventions must be performed in an aqueous medium to be effective, requiring constant and generous irrigation. After fragmentation, a percutaneous or transpapillary route can be used to remove stone remnants. Percutaneous removal requires the use of baskets or forceps for stone capture and retrograde removal. Transpapillary removal may be more practical, however, facilitated by occlusion balloons, the scope itself, and the provided irrigation.^{17,25}

Palliative photodynamic therapy may be indicated for obstructing, nonresectable, Bismuth III/IV cholangiocarcinoma. Contraindications include porphyria, porphyrin allergy, and bleeding diathesis. Improved survival and functional quality of life compared with stent placement alone has been reported.²⁶

After the indicated diagnostic or therapeutic procedure, the scope can be removed after the stiff guidewire is reinserted. Repeat cholangiography can be performed to reassess for stones and strictures, followed by biliary drainage with an internal/external drainage catheter.

Postprocedure

A similar postprocedure protocol with respect to PTBD should be utilized depending on the method of access. Severe strictures that cannot be adequately treated may require long-term drainage.²¹ If prompted by persistent symptoms or cholangiography findings at the conclusion of the procedure, a repeat cholangioscopy can be performed after 2 to 3 days of drainage.¹⁷ Rechecking bilirubin, LFTs, and an ultrasound are indicated during clinical follow-up.

Cholangioplasty and Biliary Stenting

Percutaneous transhepatic cholangioplasty with biliary stenting is a therapeutic intervention largely used for relief of obstructive jaundice and occasionally for the management of a biliary leak. Plastic stents and self-expandable metal stents are available options, but selection varies on whether strictures are benign or malignant in nature; reintervention risk and life expectancy are other considerations. Generally, malignant strictures are treated with self-expanding metal stents, whereas benign strictures or biliary leaks are treated with plastic stents.

Preprocedure Considerations

Preprocedure considerations are the same as those for PTC. Stent selection is also an important consideration. Management of malignant strictures is preferred with self-expanding metal stents, as they provide superior patency, lesser risk of reintervention, and can be performed without the need for tract maturation.²³ Benign strictures, postoperative bile leaks, and biliary stone obstructions are largely managed with plastic stents, as they are easily extractable and their decreased patency is nullified by their temporariness.²⁷ Plastic stents may still be used in patients with short life expectancy due to advanced malignancy; however, stent occlusion is a common complication.²⁸ Both plastic and metal

stents are radiopaque with proximal and distal markers to facilitate proper fluoroscopic placement. Plastic stents are made of polyethylene, polyurethane, or Teflon, and have a diameter of 5 to 12F (2–4 mm); using a 10F or larger plastic stent decreases incidence of occlusion by biliary sludge compared with smaller plastic stents.^{27,28} In contrast to plastic stents, self-expanding metal stents are composed of a flexible nitinol alloy that expands up to 30F (10 mm) when deployed through a smaller overlying sheath; occlusion is generally later and due to tumor overgrowth.^{27,28} While demonstrating better patency, the use of uncovered metal stents in benign biliary strictures is restricted by the relative difficulty in removal. Metal stents may be covered with polytetrafluoroethylene, allowing for relocation or complete extraction with a snare or forceps, and traditionally considered advantageous in the treatment of malignant strictures by improving stent patency from the prevention of tumor ingrowth^{23,27} (►Fig. 2). However, the superior patency of covered metal stents has recently been questioned in a randomized study that effectively concluded the converse was true; uncovered metal stents were significantly more effective in terms of stent patency and had lesser risk of occlusion by sludge formation and tumor ingrowth, when compared with covered metal stents.²⁹

General Procedure Technique

The procedure begins with PTC for visualization of the biliary tree. A hydrophilic guidewire and catheter should ideally be navigated around the stricture and placed in the duodenum. If initial crossing of the stricture is not possible, external PTBD should be performed and allowed to decompress the biliary system for 2 to 3 days prior to another attempt at crossing.¹ Once the guidewire is in the bowel, it is exchanged through a 5F catheter for a 0.035-in. stiff guidewire. The stricture may be dilated prior to stent placement with balloon cholangioplasty only if necessary, as this increases the risk of bleeding and subsequent hemobilia; IV fentanyl can be used during balloon dilation to improve patient comfort.^{1,23}

Self-expanding metal stents may be inserted upon initial access to the biliary tree in stable patients because of the compressibility of the metal stent into a small introducer. The stent is inserted over the 0.035-in. stiff guidewire with a 7 to 8F sheath, and positioned across the stricture according to radiopaque markings under fluoroscopic guidance.^{1,27,28} Conventionally, the distal tip of the stent should traverse the ampulla, and the stent should be fully deployed for maximal drainage and prevention of cholangitis.^{1,30} However, recent retrospective study has challenged this traditional practice, having suggested that stent insertion above the papilla is more effective at reducing rates of postprocedure infection as well as improving stent patency.³¹

In the case of Bismuth IV malignancy involving the biliary confluence, a Y stent may be placed to drain both sides.³² After the stent is fully deployed, it should maximally expand within 1 to 2 days.²³ A 5F catheter or 8 to 10F external drain may be left in the stent overnight to ensure drainage and decompression.¹

Plastic stent placement is not performed upon initial access to the biliary system, and instead requires a larger transhepatic

Fig. 2 Biliary stent placement in a patient with malignant common bile duct obstruction secondary to pancreatic cancer. (a) After prior biliary drain placement, that catheter is exchanged over a guidewire for a sheath and marking catheter. Contrast is injected from both sheath and catheter to delineate the length of the stricture (arrows). (b) After placement of a 10-mm self-expanding covered biliary stent, the stent is dilated with a 10-mm high-pressure balloon (arrow). (c) Coronal reformatted contrast-enhanced CT demonstrates stent placement through the pancreatic mass (white and black arrow) with stent tip across the ampulla into the small bowel. Pneumobilia is noted (open white arrow), indicative of stent patency. Following percutaneous transhepatic biliary drainage and stent placement, the patient's bilirubin decreased from 11.1 to 1.8 over 2 months.

tract.¹ PTC is performed followed by PTBD for several days. The drainage catheter is removed over a 0.035-in. stiff guidewire, followed by IV analgesia and serial dilation of the tract to 12F.¹ This procedure incurs more pain, higher complications of stent migration, and higher rates of occlusion by biliary sludge, and has consequently fallen out of favor.^{1,23,27} The plastic stent is introduced over the stiff guidewire with an introducer of similar diameter (in contrast to self-expandable metal stents), and positioned according to radiopaque markings under fluoroscopic guidance.^{1,27} A 5F catheter or external drain may be left in the stent overnight as well.¹

Postprocedure

After overnight drainage, cholangiography can be performed to ensure stent patency. If metal stents have inadequate expansion, balloon dilation may be required.²³ The stent may also need to be repositioned if it has migrated. When patency and position are adequate, the catheter may be removed. Similar to other biliary interventions, postoperative cholangitis and pancreatitis are potential complications. Long-term complications and cause for reintervention include stent occlusion by biliary sludge or tumor progression.

Biliary Stone Extraction

Percutaneous transhepatic biliary stone extraction is an image-guided therapeutic procedure involving bile duct cannulation and transduodenal removal of biliary stones. Extraction is commonly achieved by the use of occlusion balloons to push or sweep stones into the duodenum, potentially also facilitated by transhepatic ampullary sphincteroplasty.¹ Indications include patients with intrahepatic stones, poor surgical candidates, and/or when endoscopic intervention of the biliary tree is not technically feasible due to prior gastrointestinal surgery or anatomic anomalies. If stone fragmentation is required before expulsion, the procedure can be augmented by PTCS and intraluminal electrohydraulic lithotripsy, or by the use of Dormia basket snares.¹⁷ Combined percutaneous/endoscopic rendezvous is another alternative means of extraction not discussed here.

Preprocedure Considerations

Preprocedure considerations are the same as those for PTC.

General Procedure Technique

The procedure begins with PTC for visualization of the biliary tree and obstructing biliary stones, evidenced by filling defects if stones are free floating, or dilation with a meniscus sign if there is impaction.¹ Access points vary for intrahepatic and extrahepatic stones. With intrahepatic stones, access to the appropriate duct is absolutely necessary. For extrahepatic stones, either a left- or right-sided approach can be performed based on operator preference. If the angle of entry is too high with right-sided PTC, it may be necessary to perform a second stick with another needle into a lower (preferable segment 6) biliary duct. In the setting of cholangitis, PBD is initially necessary for decompression and resolution of the infection prior to stone extraction, which can be performed days later in a mature tract.

Once matured, the biliary drainage catheter can be exchanged over a 0.035-in. stiff guidewire for an 8 or 9F catheter and maneuvered into the duodenum; a duodenogram is performed to visualize the ampulla.¹ The catheter is removed and an 8 to 9F vascular sheath can be placed into the biliary system, through which a high-pressure balloon catheter is inserted over the stiff guidewire, and positioned in the papilla. Balloon catheters of 8 to 14 mm can be used to repeatedly dilate the papilla for 30 to 60 seconds.^{33,34} As larger diameter balloons may increase the risk of CBD rupture, the size of the largest stone on cholangiography can be used to estimate the needed papillary dilation size.^{33,35} Caution should be exercised when removing the balloon catheter to avoid dragging stones proximally into the biliary system. Balloon occlusion catheters of 10 to 20 mm can then be inserted over the guidewire and inflated with contrast proximal to the stone, and used to push the stones distally through the papilla and into the duodenum. PTCS with electrohydraulic lithotripsy can also be used prior to balloon occlusion catheter insertion to fragment stones into smaller, more manageable pieces. When the stones have cleared the papilla, the filling defect should be visible in the duodenum, as the contrast flows through the ampulla and into the small bowel. As hemobilia can result from the trauma induced by ampullary cholangioplasty and/or balloon sweep of biliary stones, the existing sheath at the completion of the procedure can be exchanged for an 8 or 10F internal/external biliary drainage catheter to prevent an iatrogenically induced biliary obstruction.

Postprocedure

A similar postprocedure protocol with respect to PTBD should be utilized depending on the method of access. Repeat cholangiography should be performed, however, to ensure normal filling of the biliary tree.^{33,34} Postoperative complications similar to PTBD include cholangitis and pancreatitis, but incomplete evacuation of stones represent an additional possibility.

Intraluminal Brachytherapy

Intraluminal brachytherapy is a percutaneous transhepatic palliative intervention that involves catheter-mediated delivery of radiation to malignant biliary strictures. Intraluminal brachytherapy treats obstructive jaundice, improves stent patency, and increases patient survival.^{23,36,37} One common indication includes malignant biliary strictures in patients who are poor surgical candidates for resection, frequently due to the degree of malignant extension and/or invasion of the hilar vasculature. Compared with external beam radiation therapy (EBRT), intraluminal brachytherapy confers several advantages that allow delivery of higher doses of radiation with better specificity to a precise volume of tissue, while better preserving the highly radiosensitive surrounding tissue.^{36,38}

Preprocedure Considerations

Preprocedure considerations are the same as those for PTC; however, the procedure is performed in a brachytherapy unit in conjunction with radiation-oncology. An Integrated Brachytherapy Unit (IBU) is used for three-dimensional planning, assessment of target volume, and verification of dosimetry. Remote

afterloading systems of Iridium-192 allow dose optimization and improve radiation safety by automating radiation delivery to predetermined positions.

General Procedure

Intraluminal brachytherapy begins with PTC for identification of strictures, PTBD under fluoroscopic guidance, and stent placement if not previously done. Generally, a 10F internal/external biliary drainage catheter can double as access for the Ir-192 applicator, thus expediting the procedure; however, a dual lumen catheter or two separate catheters can alternatively be used.³⁹ The applicator with a mock Iridium source is placed through the catheter and positioned with 1 to 2 cm margins both proximally and distally.^{36,39} The remote afterloading system with applicators is connected to the treatment planning system, which controls the dwell positions and dwell times of Iridium pellets.³⁶ The sham source is removed and Iridium-192 pellets are inserted through the catheter by the remote afterloading system to the designated position.³⁶ High dose rate (HDR) of Ir-192 is then delivered at 1 cm from the source axis with at least 6 hours between treatments, delivered in six fractions, once or twice daily.^{36,39} If combined with EBRT, total fractional delivery should be reduced. HDR is commonly used but low dose rate (LDR) and pulsed dose rate (PDR) may be used as well. LDR is delivered at 1 cm from the source axis as well, but uses less Gray/hour and is delivered after EBRT.³⁹ LDR may compromise biliary drainage, however, because the applicator must remain in the lumen for longer periods.³⁶ PDR uses hourly pulses.³⁹ After irradiation, the applicator is removed and the biliary system is left to drain.

Postprocedure

A similar postprocedure protocol with respect to PTBD should be utilized depending on the method of access, in addition to follow-up of tumor markers and regular CT scans; radiation toxicity should be assessed using Common Terminology Criteria for Adverse Events version 3.0 (CTCAE v3.0) and Radiation Therapy Oncology Group (RTOG) scores.^{40,41}

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