The rise of minimally invasive surgical techniques during the past 20 years has been one of the more dramatic developments in modern medicine. Minimally invasive procedures are now widely accepted for treatment of diseases involving many different organ systems. Minimally invasive procedures may be more common and more accepted in the treatment of diseases of the biliary tract than in any other area. The development of laparoscopic cholecystectomy serves as a benchmark for minimally invasive procedures, and it is now the standard of care for the treatment of cholelithiasis. Today, not only is laparoscopic cholecystectomy one of the most common operations performed in the United States, but many new techniques have been developed that allow minimally invasive treatment of a variety of biliary tract diseases. The development of nonoperative techniques for treatment of biliary tract disease has accompanied the rapid developments in minimally invasive surgical techniques. This article describes the nonoperative treatment of biliary tract disease.

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usually preferred. The second consideration in choosing an access route is the location of the biliary pathologic lesion. Lesions in the distal common bile duct are more easily accessed using ERCP, while biliary hilar or intrahepatic lesions are more easily approached using PTC. Lesions in the mid–common bile duct can be readily approached with either access method. Taken together, consideration of the expertise available at the institution, the presence of coagulopathy, the caliber of the intrahepatic bile ducts, and the location of the lesion to be treated allows an appropriate choice of access for nonoperative procedures in the biliary system.

**TREATMENT OF BENIGN BILIARY STRICTURES**

Nonoperative techniques have become a first-line treatment for benign biliary strictures of various causes. Among the most common types of benign strictures treated nonoperatively are traumatic strictures, anastomotic strictures, and strictures secondary to primary sclerosing cholangitis (Figure 2). Traumatic biliary strictures are most frequently seen after iatrogenic injury occurring during laparoscopic cholecystectomy. In addition, these types of strictures can occur after external trauma involving direct injury to the biliary tree or to the vascular supply to the bile ducts. Anastomotic strictures after biliary enteric anastomoses are a common problem. In most cases, these strictures must be treated via the percutaneous transhepatic route since the creation of a Roux-en-Y loop at the time of anastomosis prohibits access to the biliary system via endoscopy. Alternatively, some surgeons have advocated creation of a subcutaneous small-bowel loop at the time of biliary enteric anastomosis. This loop can be marked with radiopaque surgical slips to allow the radiologist direct percutaneous access to the anastomosis without requiring a transhepatic approach. Strictures secondary to primary sclerosing cholangitis are usually best treated using an endoscopic approach. This method avoids the risk associated with the transhepatic approach and also decreases the chance of introducing infection into the peripheral biliary tree.

Regardless of the cause of the benign stricture, once access to the stricture has been gained, treatment begins with the performance of a cholangiogram to delineate the anatomy of the stricture (Figure 2, A). A guidewire followed by a balloon dilatation catheter is then placed across the stricture (Figure 2, B). Balloons 6 to 10 mm in diameter are usually used and allow adequate dilatation of most biliary strictures without an undue risk of duct injury. While balloon pressures can be monitored, this is not essential as the adequacy of the dilatation is best monitored using fluoroscopy. Using fluoroscopic guidance, dilatation continues until reduction of the waist of the balloon at the site of stricture has been achieved (Figure 2, B). The balloon is then removed and a second cholangiogram is performed to document improvement or resolution of the stricture.
(Figure 2, C). If the cholangiogram demonstrates relief of obstruction with free flow of contrast into the duodenum and if no further dilatations are anticipated, then the procedure is discontinued. If residual obstruction is present or if further dilatations are planned, then a biliary drain is left in place. The biliary drain allows decompression of the biliary system and also preserves access to the biliary tree for future intervention. The results of nonoperative treatment of benign strictures vary depending on the cause and site of the stricture being treated. In general, with new strictures, a 5-year biliary patency rate of 70% to 85% can be achieved.1

DIAGNOSIS AND TREATMENT OF BILIARY MALIGNANT NEOPLASMS

Surgical resection offers the best chance of cure in patients with biliary malignant neoplasms. Therefore, any patient with a resectable tumor and no contraindication should undergo surgery. For patients with unresectable disease, nonoperative techniques are extremely useful for both diagnosis and palliation. When a biliary neoplasm is suspected based on findings of computed tomographic or ultrasonographic studies, percutaneous biopsy can be used to obtain a definite tissue diagnosis. Prior to biopsy, the patient is evaluated to ensure that the platelet count is adequate (>50 × 10^9/L) and that no coagulopathy exists (INR, <1.4). Provided no contraindication is present, a biopsy specimen can be obtained. Computed tomographic or ultrasonographic guidance can be used to obtain either fine-needle aspiration biopsy specimens or core biopsy specimens of the lesion in question. Fine-needle aspiration biopsy specimens are obtained using a 20- or 22-gauge Chiba needle (Figure 3). Core biopsy specimens can be obtained using a trucut-type needle. Regardless of the method used to obtain a biopsy specimen, it is important that a pathologist be present to judge the adequacy of the specimen. Once an adequate specimen is obtained, the procedure is discontinued. Alternatively, if percutaneous biopsy specimens are inadequate for providing a tissue diagnosis, the biliary system can be accessed by either the transhepatic or endoscopic approach and biliary brushings can be acquired for cytological analysis.

The second application of nonoperative procedures in patients with biliary malignant neoplasms is for...
the nonoperative palliation of symptomatic disease. These patients frequently develop pain and jaundice as a result of obstruction due to malignant neoplasms in the biliary system. Nonoperative treatment of obstruction allows relief of symptoms without subjecting the patient to the risks of open surgery. After establishing that the patient has a normal platelet count and coagulation factors, a route of access to the biliary tree is chosen. In general, strictures in the middle or distal common bile duct are approached endoscopically, while hilar strictures are approached via the transhepatic route. A preliminary cholangiogram is obtained to delineate the anatomy of the stricture. The first step in nonoperative management of a stricture due to malignant neoplasm is placement of an external biliary drain. A drainage catheter with multiple side holes is placed within the biliary tree to a level just proximal to the obstruction. The external portion of the catheter is connected to a drainage bag for decompression of the biliary system.

Once adequate biliary decompression has been achieved, the external drain can be exchanged for either an external-internal drain or an indwelling endoprosthesis. With external-internal drainage, a catheter is positioned with side holes proximal and distal to the stricture (Figure 4). Biliary drainage can then flow retrograde to an external collection bag or antegrade into the duodenum. Once antegrade flow is adequate to maintain biliary decompression, the drainage bag is removed and the external portion of the catheter is capped. The primary advantage of external-internal drainage is that this technique maintains access to the biliary tree in case any future intervention is needed. The disadvantage of this method is that the external portion of the drain may be poorly tolerated by the patient.

A second option for long-term management of a biliary stricture due to malignant neoplasm is the placement of an indwelling endoprosthesis or biliary stent (Figure 5). Two types of biliary stents are available: plastic and metallic. The metallic stents have demonstrated a significantly greater long-term patency rate and have essentially superseded their plastic precursors. These stents are introduced over a 7F catheter that is placed across the area of stricture. The stents then self-expand to a diameter as large as 12F. A temporary external catheter is left in place at the time of stent placement, and a repeated cholangiogram is performed the following day. If the cholangiogram demonstrates free flow of contrast past the stricture through the biliary stent, the drainage catheter is removed and the stent is left in place. Because these stents are indwelling, they are better tolerated by patients than external-internal drainage. Unfortunately, placement of an indwelling stent implies loss of access to the biliary tree, which must be reobtained if any further interventional procedure becomes necessary. The combination of external drainage, external-internal drainage, and biliary stenting is usually sufficient to provide palliation of the symptoms of obstruction due to malignant neoplasm for the duration of the patient's life.

MANAGEMENT OF COMPLICATIONS OF LAPAROSCOPIC CHOLECYSTECTOMY

A final area in which several of the techniques already described are combined for treatment of biliary tract disease is in the management of problems or complications arising after laparoscopic cholecystectomy. The 2 most significant problems are retained common bile duct stones and iatrogenic bile duct injuries.

Retained common bile duct stones are a well-recognized problem associated with both open and laparoscopic cholecystectomy. Choledocholithiasis encountered during open cholecystectomy is treated with relative ease by common bile duct exploration and stone extraction. When common bile duct calculi are encountered during laparoscopy, however, the surgeon is faced with a difficult problem. Three options are available for dealing with
choledocholithiasis discovered at the time of laparoscopic cholecystectomy. First, the surgeon can convert to an open procedure and perform traditional common bile duct exploration and stone extraction. Unfortunately, this option requires laparotomy and thereby nullifies the advantages of the minimally invasive cholecystectomy. A second option for treating unexpected common bile duct stones discovered at laparoscopic cholecystectomy is to proceed with laparoscopic common bile duct exploration. This technique is attractive in that it does not require converting to an open procedure, but laparoscopic common bile duct exploration is technically demanding and not in the usual armamentarium of many surgeons. A third option for dealing with choledocholithiasis in this setting is to complete the laparoscopic cholecystectomy without performing stone extraction and to plan on follow-up ERCP for extraction of common bile duct stones.

Endoscopic retrograde cholangiopancreatography for retrieval of retained common bile duct stones can be performed at any time after laparoscopic cholecystectomy. At the time of ERCP, the common bile duct is cannulated and a preliminary cholangiogram is obtained. Stones observed on this cholangiogram can be handled in several ways. Most often an uninflated balloon catheter is passed retrograde into the duct beyond the calculi to be retrieved. The balloon is then inflated and the catheter is pulled out of the duct, thereby pulling the calculi with it. If the balloon technique is unsuccessful, the calculi can be grasped with a snare basket and pulled from the duct in this fashion. If the stones to be extracted are too large to be removed with the balloon or basket device, a rotary stone-crushing device can be passed into the duct to break stones into smaller fragments. Alternatively, stones can be fragmented using an endoscopic lithotripsy device or laser. The smaller fragments may then pass spontaneously out of the common bile duct and into the duodenum or may require extraction with the balloon or basket devices. Using these techniques, more than 90% of common bile duct stones found during laparoscopic cholecystectomy can be successfully retrieved at the time of follow-up ERCP.3

A second complication of laparoscopic cholecystectomy that is frequently treated using nonoperative techniques is iatrogenic bile duct injury. According to the literature, the rate of bile duct injuries during open cholecystectomy is approximately 0.1% to 0.2%. The incidence of duct injury at laparoscopic cholecystec-
tomy, while still low, rises to 0.2% to 0.5% and may be as high as 2.2% during the first several laparoscopic procedures that a surgeon performs.4 The nonoperative treatment of bile duct injuries involves 4 basic techniques that have been described herein: cholangiography for diagnosis of the biliary tract injury; balloon dilatation for treatment of the biliary stricture; biliary drainage to allow decompression of the biliary system, which is essential for uncomplicated healing; and percutaneous drainage of fluid collections associated with the bile duct injury. Using these techniques, the management of common bile duct injuries has been significantly affected. In a recent study5 of 45 patients with common bile duct injuries, 30 patients were successfully treated nonoperatively using nonoperative techniques. In several of the remaining patients, nonoperative procedures were used as an adjunct to surgery.3

CONCLUSIONS

Nonoperative treatment of biliary disease has progressed rapidly since the advent of laparoscopic cholecystectomy. Interventional procedures including percutaneous biopsy, dilatation of biliary strictures, and drainage and stenting of the biliary tree have become common. These treatment modalities are used both as first-line treatments and adjuncts to surgical therapy in patients with benign and malignant diseases of the biliary system.

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REFERENCES