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OBSTRUCTIVE JAUNDICE: PERCUTANEOUS TRANSHEPATIC INTERVENTIONS

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Percutaneous, nonoperative management of obstructive jaundice is determined by the cause of the bile duct obstruction, the clinical findings at presentation, pertinent laboratory data, and results of diagnostic imaging studies. Most patients referred for percutaneous interventional biliary techniques are under evaluation for surgical treatment, and these procedures have become closely integrated with surgical protocols. Consequently, the percutaneous nonoperative treatment algorithm is influenced by whether or not the patient is a surgical candidate.

Advances in diagnostic imaging have significantly improved management of obstructive jaundice. At the time of the percutaneous intervention, it is not uncommon to be relatively certain of the cause and level of biliary obstruction on the basis of cross-sectional imaging. Specific diagnostic information is further enhanced by percutaneous and/or endoscopic cholangiography. Endoscopic retrograde cholangiography (ERC) demonstrates detailed anatomy of the extrahepatic bile ducts and is often performed as the first invasive diagnostic procedure. The advantages of ERC include the ability to define the anatomy of the extrahepatic bile ducts without the significant discomfort and potential risks associated with percutaneous transhepatic procedures. This is especially true in a patient with coagulopathy or marked ascites. The limitations of ERC in the evaluation of a patient with bile duct obstruction include (1) incomplete filling of the intrahepatic bile ducts with contrast, (2) poor delineation of lengthy bile duct lesions, and (3) inability to technically cannulate the biliary system owing to surgically altered anatomy (i.e., most biliary-enteric anastomoses). In preoperative surgical assessment of the patient, it is the anatomy of the intrahepatic bile ducts that is most important in planning the biliary-enteric anastomosis. Direct visualization of the bile ducts by percutaneous transhepatic cholangiography (PTC) is therefore preferred in the preoperative assessment of obstructive jaundice, since the intrahepatic biliary tree is generally well delineated, and lesion length and multiplicity are easily defined. If the patient has an obstruction at the bifurcation or has isolated ducts due to tumor or benign strictures, PTC/PBD (percutaneous biliary drainage) may be required bilaterally; e.g., right and left sides. We also feel that PTC is the procedure of choice when biliary obstruction occurs postoperatively or when the management of palliative bile duct stenting is planned.

PTC is the first step to a PBD procedure. Because PTC provides adequate visualization of the intrahepatic bile ducts, accurate needle placement under fluoroscopic guidance for transhepatic biliary access is possible. Multidirectional C-arm fluoroscopy and advances in catheter and guidewire technology have improved the overall technical success rate for PBD. It is rare that complete obstructions of the common bile duct cannot be crossed on the initial intervention with new hydrophilic catheters and guidewires, allowing placement of the transhepatic internal/external biliary drainage catheter. Internal/external biliary stenting provides effective decompression of the obstructed biliary system with open access to tube and enteric drainage. In the setting of biliary sepsis, PBD can be a lifesaving procedure. Bile aspirate is available during PTC/PBD for Gram's stain and culture and sensitivity, and prompt relief of bile duct obstruction rapidly facilitates stabilization of the septic patient. In spite of improved technology, the risks of PBD remain unchanged. Cholangitis is the most common problem after percutaneous drainage and has been reported to occur in as many as 18 percent of cases, while sepsis is seen in 3 to 4 percent. Hemobilia may also become a significant complication of percutaneous drainage. Tamponade of the transhepatic tract by the percutaneous tube resolves most cases of hemobilia (especially venous) in the first 24 to 48 hours; however, late bleeding from a pseudoaneurysm of a hepatic artery branch, requiring percutaneous transcatheter embolization, may occur in 3 percent of patients after PBD. The reported mortality rate of PTC/PBD is 0.6 to 3 percent. ERC is reported to have lowered complication rates, and thus is often preferred for initial cholangiographic evaluation of suspected bile duct obstruction, especially in the patient with nondilated ducts. Other endoscopic biliary interventions, including sphincterotomy, stent placement, and other advanced techniques, do have significant complications (e.g., pancreatitis, cholangitis, sepsis). Mortality from endoscopic interventions has been as low as 1 percent and as high as 9 percent.

In our institution, a combined nonoperative percu-

taneous and surgical approach has been successful in treating a wide variety of obstructive bile duct lesions. As a result of multispecialty interest, nonoperative percutaneous techniques have been encouraged with the development of better methods of dealing with postoperative complications and alternative forms of therapy for the nonoperative patient.

MALIGNANT OBSTRUCTION

Neoplastic obstruction of the proximal bile duct, common hepatic duct, and hilum is most often due to cholangiocarcinoma. Metastasis may occasionally result in the same radiographic findings on PTC. Cholangiocarcinoma may extend into one or multiple hepatic ducts. Encasement of the hepatic artery or portal vein by scirrhous tumor is not uncommon by the time the patient is clinically jaundiced. Death usually occurs within 6 to 12 months, related to local extension of tumor, effects of bile duct obstruction (hepatic dysfunction), and cholangitis. Preoperative evaluation includes ultrasonography, computed tomography (CT), magnetic resonance imaging, percutaneous cholangiography, and angiography (including arterial portography). Patients considered operative candidates undergo PBD. If both right and left biliary ducts are involved, PBD catheters (stents) are inserted on each side, crossing the lesions and entering the duodenum. Preoperative status is enhanced by improved liver function and, when necessary, supplemental hyperalimentation. The percutaneous stents facilitate identification of the bile duct anatomy during surgical resection of tumors, especially when they have invaded the liver hilum. PBD catheters also aid surgical placement of transhepatic Silastic stents during creation of the hepaticojejunostomy anastomosis. Cameron and associates have shown good results in altering the natural history of cholangiocarcinoma with aggressive surgical resection. Operative percutaneous stenting is valuable in the long-term follow-up of these patients. The internal/external percutaneous stents allow postoperative cholangiography to be performed to check for bile leak, stricture formation, and recurrent tumor and as a means of access for management of these complications. Late complications such as stricture and stone formation may be treated by percutaneous methods, including balloon cholangioplasty, stone removal with retrieval baskets, and choledochoscopy using electrohydraulic lithotripsy for stone fragmentation. The choledochoscope allows direct fiberoptic visualization of postoperative strictures and guides the interventional radiologist during biliary biopsy. Recurrence and extension of tumor often requires additional percutaneous drainage of isolated and obstructed bile ducts.

Nonoperative patients are those who have (1) underlying medical conditions that make them a high surgical risk; (2) tumors unresectable by CT, cholangiography, and angiography; or (3) metastatic disease. Unlike endoscopically placed stents in which drainage of proximal bile duct lesions may not be adequate, percutaneous drainage is the palliative procedure of choice. Percutaneous access allows accurate placement of large-caliber internal/external stents above proximal bile duct obstructions, and these can be easily exchanged if clogged with thick bile or small bowel secretions.

If lobar atrophy is present on CT scan because of neoplastic encasement of ductal and vascular structures, and if the bile ducts do not fill by contralateral cholangiography, percutaneous drainage of the atrophied lobe offers little advantage. In this situation, stasis and cholangitis can easily complicate the PBD procedure.

Successful palliation with iridium 192 in a limited number of patients has been reported by Nunnerly and colleagues. Percutaneous biliary stents provide the access for placement of the iridium 192–seeded wires, which deliver local high-dose radiation to the tumor. However, use of brachytherapy in the palliation of bile duct malignant obstruction remains controversial and is an area of active clinical investigation.

Biliary endoprostheses, both percutaneously and endoscopically placed, have been used to palliate patients with hilar cholangiocarcinoma. Percutaneously placed plastic endoprostheses are usually 12 to 14 Fr and are larger than endoscopic stents. Stent patency is usually about 6 months, therefore, these are used in patients with limited life expectancy. Endoscopic endoprosthesis failure is often due to poor drainage of obstructed bile ducts at the liver hilum, poor long-term patency, and stent dislodgment. Clinical experience with metallic endoprostheses in proximal bile duct tumors has also been poor. Percutaneous stenting with large-caliber, soft Silastic stents remains the preferred palliative drainage procedure in patients with malignant obstruction of the proximal bile ducts. The definitive treatment of malignant obstruction of the distal common bile duct, including pancreatic and periampullary carcinoma, is curative surgical resection. Preoperative PTC is performed for diagnostic information and surgical planning. PBD and the percutaneously placed drainage catheter provide intraoperative control of the common bile duct during resection and enable surgical decompression of the biliary enteric anastomosis postoperatively.

In patients with unresectable distal common bile duct and periampullary disease, however, palliation with endoscopically placed stents is preferred, since adequate drainage can be achieved without the morbidity and mortality associated with percutaneously placed stents. The technical and clinical success in draining distal common bile duct malignant obstructions is approximately equal for percutaneous and endoscopically placed stents. When the endoscopic stents become obstructed or dislodged, they can be exchanged with little patient discomfort.

With improved metallic stent technology, placement of metallic endoprostheses can be achieved either percutaneously or endoscopically (Fig. 1). Self-expanding metallic stents allow percutaneous placement by a small transhepatic tract (7 Fr) and, when unsheathed, provide large-caliber stenting of the neoplastic obstruction (8,

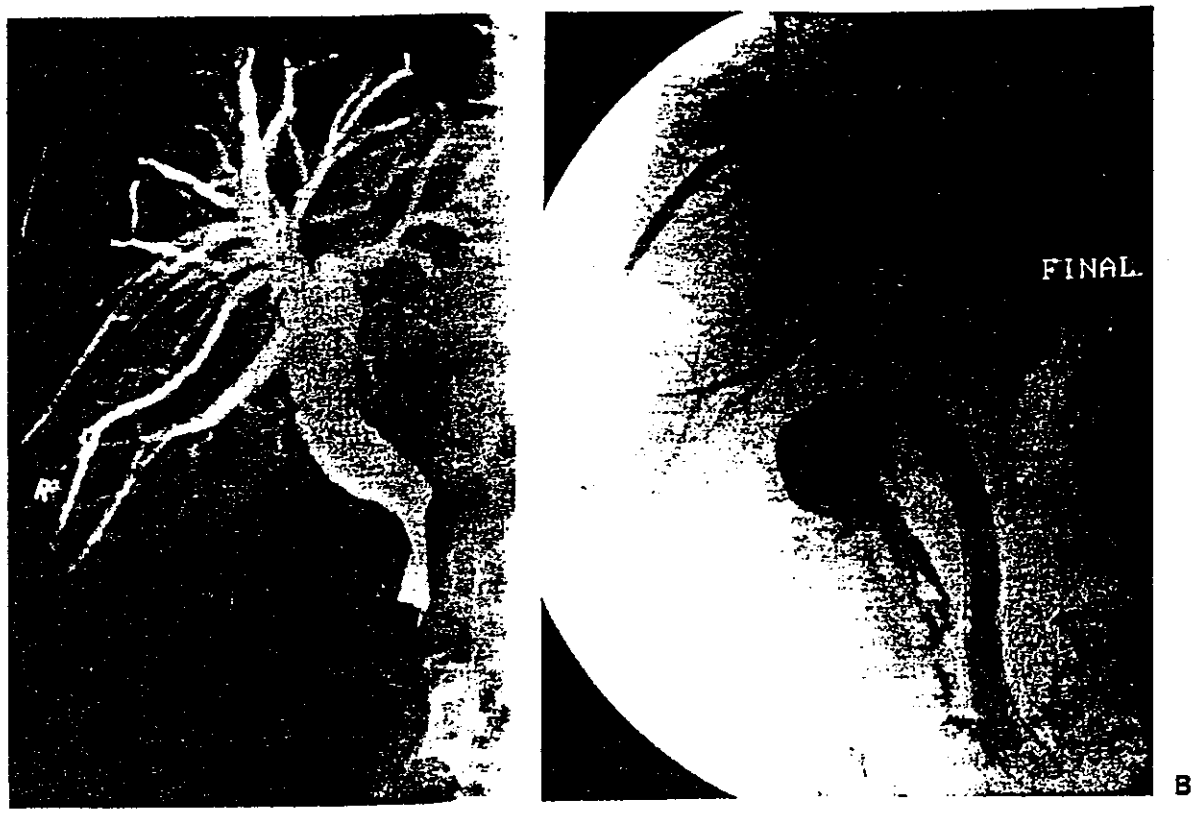

Figure 1 *A*, Transhepatic cholangiogram demonstrating total occlusion of the common bile duct due to unresectable pancreatic cancer. *B*, Metallic Wallstent endoprosthesis used to maintain a patent lumen through the neoplastic obstruction. The stent was inserted after balloon dilatation and provides a 10 mm lumen for adequate biliary drainage.

10, and 12 mm). We do not advocate the use of metallic stents in hilar cholangiocarcinoma, because of the technical difficulties of stent placement. Hilar cholangiocarcinoma tends to involve the bifurcation requiring multiple stents. Furthermore, long-term patency of stents is complicated by tumor overgrowth at more than one site.

Metallic or plastic endoprostheses may be used for distal common bile duct obstruction since such lesions are localized to the distal common bile duct and patency of a single channel is easier to maintain. Unlike the plastic endoprosthesis, the metallic stent cannot be removed when obstructed. Obstruction requires repeat percutaneous drainage and either restenting with a new metallic endoprosthesis or use of transhepatic PBD catheters. Long-term survival, patency, morbidity, and procedural mortality rates are favorable for treatment of distal malignant obstruction with percutaneously or endoscopically placed metallic stents. A recent European multicenter study indicates equal success for treatment of hilar lesions. Mean patency for all stents has been 7 months of stent occlusions; 24 percent required repeat transhepatic access and restenting. Causes of metallic stent failure include ingrowth of tumor through stent interstices (infrequent) and more frequently overgrowth of tumor at the proximal or distal margins of the stent. We prefer to use these stents in patients with limited life expectancy and distal common bile duct neoplastic obstructions. These lesions are technically easier to bridge with the stent, with adequate proximal and distal coverage.

BENIGN BILIARY STRICTURE

Benign strictures of the biliary tree may present a difficult management problem. The majority of benign strictures are the result of bile duct injury from surgical procedures on the biliary tree. Strictures can also occur at the site of biliary-enteric anastomoses. Primary strictures of the common bile duct most commonly occur from chronic cholelithiasis, choledocholithiasis, chronic pancreatitis, or sclerosing cholangitis.

In a patient with common bile duct injury, jaundice is usually the mode of clinical presentation. Symptoms of cholangitis may also be present at this time. Ultrasonography and CT scan are useful for indicating the presence of dilated ducts and the level of obstruction. Most benign strictures due to bile duct injury occur in the common hepatic or proximal common bile duct. As in the evaluation of patients with malignant biliary obstruction, cholangiography provides valuable information about the biliary anatomy as it relates to surgical revision. PTC is preferable to ERC, since the proximal bile ducts are

better visualized, and it is the proximal anatomy that is essential for surgical planning.

In patients with benign biliary strictures and significant obstructive jaundice, cholangitis, or sepsis, PBD is usually performed preoperatively. Operative repair of the bile duct stricture is often the procedure of choice unless a previous repair or biliary-enteric anastomosis has been performed. After primary operative repair, patient management includes postoperative cholangiography, biliary decompression, and percutaneous stenting. When operative repair requires hepaticojejunostomy and when poor mucosal continuity occurs at the anastomotic site, long-term percutaneous stenting is required for adequate anastomotic patency.

Strictures that occur after repair of the common bile duct or at biliary-enteric anastomoses may be approached nonoperatively. With indwelling, percutaneously placed stents, anastomotic strictures may be balloon dilated (cholangioplasty). Such lesions are often firm, causing a tight constriction on the dilatation balloon, and 6 to 8 atmospheres of pressure may be required to achieve complete dilatation of the stricture. The degree of dilatation and the size of the balloon are usually estimated on the basis of the diameter of the bile ducts involved in the anastomosis. Most balloon dilatations are adequate at 8 mm in diameter, although some investigators advocate significant "overdilatation." Large-caliber stents are placed after cholangioplasty for biliary decompression, maintenance of the anastomotic channel during healing, and follow-up cholangiography and as a means of access for repeat dilatation if necessary. The duration of stenting is controversial, but most patients at our institution are stented for a minimum of 3 months after balloon dilatation. If follow-up cholangiograms appear satisfactory 3 months after dilatation, the biliary anastomotic stent is exchanged for a short PBD catheter of the same caliber but placed above the area of former stricture. The tube is capped for 1 to 2 weeks of outpatient observation. Any signs or symptoms of cholangitis or of right upper quadrant pain indicate failure of the clinical trial. After the clinical trial (or at the return of symptoms), cholangiography is performed. If restenosis has occurred on cholangiography and the patient has recurrent symptoms, the stricture is reintubated by advancing the biliary stent. Repeat balloon dilatation with stenting or surgery is then considered. If the patient is asymptomatic and restenosis is not present or insignificant on cholangiography, a biliary Whitaker (biliary manometric perfusion) test is performed. Dilute contrast infusion of the percutaneous stent results in a fluid challenge to the biliary tree with intermittent pressure monitoring. The technique was popularized by Beinart and vanSonnenburg and provides some objective criteria for evaluation of the capacity for bile flow through the ductal system in the presence of stricture. In patients with successful balloon dilatation, an asymptomatic clinical trial, and normal pressures during the biliary Whitaker test, patency rates of approximately 90 percent can be expected at 1 year.

Published data for percutaneous balloon dilatation and stenting indicate long-term patency rates of 55 to 76 percent with follow-up periods of 5 and 3 years, respectively. Most data on percutaneous dilatation and stenting of patients with benign biliary strictures are retrospective and cover limited numbers of patients. Long-term patency rates at our institution for surgical repair of similar lesions are 89 percent at 72 months follow-up. Initial reports of percutaneous balloon dilatation showed significant complications of hemobilia, most of which were related to the transhepatic access procedure. A more recent multicenter review of cases revealed a 5 percent complication rate, primarily due to cholangitis with no hemobilia or patient mortality.

In cases of sclerosing cholangitis, operative resection of dominant strictures in the extrahepatic bile ducts or at the bifurcation is advocated for most symptomatic patients. PTC has been shown to be of value in the diagnosis of sclerosing cholangitis, with good opacification of the intrahepatic bile ducts and delineation of intrahepatic strictures. PBD is valuable for adequate preoperative treatment of significant cholestasis or cholangitis. Nonoperative percutaneous management of sclerosing cholangitis remains controversial, and clinical data describing good long-term results are limited. In nonoperative patients with long-standing cholestasis, fibrosis, and cirrhosis, percutaneous balloon dilatation of dominant strictures may minimize bouts of cholangitis and prolong liver function until hepatic transplantation is feasible. If the patient has strictures of the extrahepatic ducts and no percutaneous access, ERC with balloon dilatation may also be performed.

STONE DISEASE

Biliary tract stone disease, which is amenable to percutaneous management, includes retained common bile duct calculi, choledocholithiasis, and primary hepatolithiasis. Endoscopic treatment of retained common bile duct stones or choledocholithiasis is preferred to percutaneous management, since sphincterotomy is often effective for adequate stone clearance without the associated risks of transhepatic drainage. However, sphincterotomy and bile duct manipulation with stone retrieval baskets and subsequent stenting can be associated with significant morbidity (pancreatitis, cholangitis, sepsis) and a mortality rate varying from 1 to 9 percent. In our opinion, a large-caliber T-tube tract offers a valuable percutaneous access for choledochoscopy. When this technique is combined with stone basket retrieval or electrohydraulic lithotripsy, stone clearance is successful in almost all cases, with very little patient morbidity. A large T-tube (14 to 16 Fr) tract will permit the use of a flexible 9 or 15.5 Fr choledochoscope.

If the percutaneous tract is unacceptably small, an interval tube exchange for a larger-caliber stent can be performed beginning at least 3 to 4 weeks after surgery. At our institution, percutaneous choledochoscopy to remove retained biliary calculi is preferred to conven-

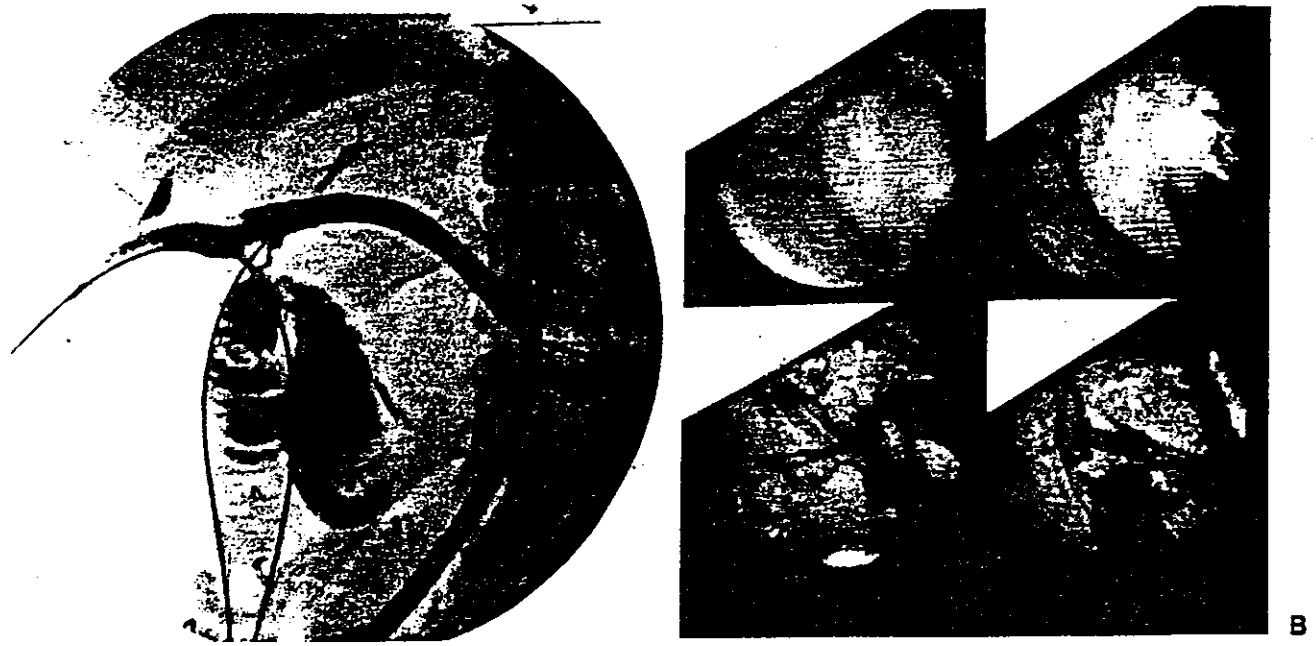

Figure 2 *A*, Bilateral percutaneous stenting of a hepaticojejunostomy with Heyer-Schulte Silastic stents in a patient with common bile duct injury. Both stents have been replaced with guidewires, and a choledochoscope has been passed into the left duct. A filling defect represents a retained calculus from previous cholecystectomy. *B*, View of the calculus (*arrow*) from the choledochoscope at the biliary-enteric anastomosis. Electrohydraulic lithotripsy resulted in fragmentation of the stone (*open arrow*) so that passage through the anastomosis was possible.

tional fluoroscopically guided stone retrieval techniques. Directional catheters and stone retrieval baskets utilizing fluoroscopic imaging alone result in excessive radiation exposure to the patient and to the hands of the interventional radiologist. Choledochoscopy facilitates stone retrieval and removal with manipulation of the stone basket under direct vision; it also permits use of electrohydraulic lithotripsy for fragmentation of large calculi that cannot be removed through the percutaneous tract. The small stone fragments can be removed percutaneously or pushed through a previously balloon-dilated ampulla.

In patients with primary hepatolithiasis, the natural history of the disease is progressive biliary obstruction, cholangitis, cholangitic abscess, bile duct stricture, and liver failure. Ultimately, cirrhosis and portal hypertension may result. Endoscopic techniques are often insufficient for stone clearance or adequate dilatation of intrahepatic strictures. Techniques using intraoperative choledochoscopy and radical biliary dissection with Roux-en-Y hepaticojejunostomy have stone retention rates of 33 percent. We advocate combined percutaneous and surgical management of these patients. Preoperatively, PTC and PBD are performed. Surgical intervention is directed at correction of underlying bile duct strictures with resection of diseased ducts, removal of readily accessible stones, and creation of a hepaticojejunostomy, followed by operative anastomotic intubation using the percutaneously placed stents. Postoperatively, patients are evaluated by cholangiography. Percutaneous choledochoscopy utilizing stone fragmentation, retrieval of fragments, and cholangioplasty are techniques employed when retained stones are present. The combined approach has resulted in favorable outcomes in our treatment group of 54 patients. At a mean follow-up of 60 months, 87 percent were alive and symptom free. Ninety-four percent of patients remained stone free at the end of the follow-up period. In ten patients, percutaneous management was the only therapy when recurrent stone disease was discovered (Fig. 2). Complete stone clearance was achieved in all ten patients, with an average of 1.8 choledochoscopies and 0.5 cholangioplasties per patient. Of the ten patients, one had a mild self-limiting complication of cholangitis, treated with antibiotics.

Percutaneous management of intrahepatic stones requires PTC and drainage on initial patient admission. Tract size can usually be increased over a period of 5 days to 16 Fr if there are no complications of cholangitis or sepsis. The tract is allowed to mature for 3 to 4 weeks. The patient may then be treated on an outpatient basis with choledochoscopy and stone removal. In patients with excessive stone burden, multiple sessions of percutaneous choledochoscopy may be required on an inpatient basis. In all cases, intravenous antibiotics and adequate postoperative monitoring for cholangitis or sepsis are required. Hepatolithiasis involving both lobes of the liver usually requires bilateral biliary stents and a more protracted inpatient/outpatient management protocol.

COMMENTS

Percutaneous, minimally invasive techniques will continue to evolve in a health care environment that emphasizes lower-cost procedures and ambulatory care. We have found that these techniques are most useful when combined with a comprehensive team approach to patient management and close association between the surgeon and interventional radiologist. Data from clinical research and evaluation of patient outcomes will ultimately determine the manner in which percutaneous interventional techniques are employed.

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OBSTRUCTIVE JAUNDICE: ENDOSCOPIC MANAGEMENT

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Obstruction of the bile ducts can have a variety of causes, but the common causes are gallstones; carcinoma of the pancreas, gallbladder, and bile duct; metastases; and sclerosing cholangitis. Rare causes include papillary tumors, postoperative strictures, chronic pancreatitis, papillary stenosis, acquired immunodeficiency syndrome (AIDS)-related cholangiopathy, sphincter of Oddi dysfunction, ascariasis, and liver flukes. The management of obstructive jaundice depends on the etiology, the comorbid conditions, resectability in the case of malignant tumors, and (most importantly) the local expertise.

ENDOSCOPIC RETROGRADE CHOLANGIOPANCREATOGRAPHY (ERCP)

Endoscopic cannulation of the papilla of Vater was initially described in 1968, since when ERCP has become one of the most reliable methods of diagnosing biliary obstruction. An experienced endoscopist can selectively cannulate the bile duct and pancreatic duct in 95 percent of cases. A variety of cannulation catheters, guidewires, glidewires, and papillotomes is currently available, which has facilitated the cannulation and the therapeutic procedures with minimal morbidity and mortality of the patient. Therapeutic ERCP is a combined radiologic, endoscopic, and surgical method performed with conscious sedation. The endoscopist who performs these procedures should have adequate knowledge about conscious sedation and, more importantly, should know when to terminate the procedure because of technical difficulty or patient discomfort. Antibiotic prophylaxis should be given to immunosuppressed patients and those with bile duct stones or strictures. Patients who undergo ERCP should be checked for prothrombin time and platelet count. A careful bleeding history should be taken, and patients should be instructed to avoid aspirin and other nonsteroidal anti-inflammatory drugs for a week before the procedure. Endoscopists who do not have the skills to perform therapeutic procedures should be discouraged from undertaking diagnostic procedures, since they may do more harm by introducing infection via injection of contrast material into an obstructed biliary tree without the ability to drain it.

Endoscopic Sphincterotomy

Endoscopic sphincterotomy was initially described in 1973 and has dramatically changed the management of retained bile duct stones. Several types of papillotomes are available, including precut needle knives and precut papillotomes. The endoscopist should try to become familiar with two or three of these papillotomes to increase the safety of the procedure. Precut papillotomes or precut needle knives should be used only by experienced endoscopists when other methods of deep cannulation fail. In our experience, deep cannulation of "difficult" bile ducts can be achieved in most cases with

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