Complications of the Extrahepatic Biliary Surgery in Companion Animals

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- Extrahepatic biliary tract obstruction  •  Gallbladder
- Hemorrhage

The earliest documented diagnosis of gall stones dates back to the twenty-first Egyptian Dynasty (1085–945 BC), although cholelithiasis was not recognized as a clinical condition in human subjects until the 5th century AD and the earliest recorded cholecystectomy performed in a living patient did not occur for another 1300 years.¹,² Physicians continue to struggle with the diagnosis and treatment of extrahepatic biliary disease in human patients today.

The recognition and treatment of extrahepatic biliary tract (EHB) disease in small animals has been equally challenging. Although the vague clinical signs associated with extrahepatic biliary disease in small animals often delayed recognition and treatment of the condition in the past, the technological advances in veterinary diagnostic imaging have largely removed this obstacle. However, the recent veterinary literature continues to reflect a poor overall outcome for dogs and cats undergoing surgery of the EHB. A conservative estimate for survival in dogs undergoing surgery of the extrahepatic biliary tract is (140/220) is 63.6% and for cats is (28/68) 41%.³–¹⁶ The mortality rate in cats that undergo surgical intervention for EHB is nearly 100% when neoplasia is involved.⁵ The high mortality associated with surgery of the EHB is related not only to technical errors made during surgical procedures but is compounded by the complex pathophysiology of hepatobiliary disease, which has broad effects on wound healing, hemostasis, and sepsis. The recognition and thorough understanding of possible pathophysiologic and surgical complications associated with diseases of the extrahepatic biliary tract is the first step in achieving an improved outcome for small animals undergoing surgery of the EHB.

ANATOMY AND PHYSIOLOGY OF THE EXTRAHEPATIC BILIARY SYSTEM

The canine extrahepatic biliary system is composed of the gallbladder, the cystic duct, hepatic ducts, the common bile duct, and the major duodenal papilla. In dogs,
bile flows from the bile canniliculi into the interlobular ducts and into the lobar ducts before leaving the liver. Lobar ducts drain into hepatic ducts, through which bile passes into the common bile duct.\textsuperscript{17,18} The gallbladder lies within a fossa between the right medial and quadrate lobes of the liver. The gallbladder is drained by the cystic duct which joins with hepatic ducts to form what is often termed the “common bile duct.” It should be noted that although the term “common bile duct” is used frequently in the veterinary literature, this structure is identified simply as the “bile duct” in the standard anatomical text.\textsuperscript{19} Throughout the following text, common bile duct and bile duct will be used interchangeably. In dogs the common bile duct terminates near the minor pancreatic duct at the major duodenal papilla. In a medium-sized dog the common bile duct is approximately 5 cm long and 2.5 mm in diameter, emptying into the duodenum 1.5 to 6 cm distal to the pylorus at the major duodenal papilla after coursing intramurally for approximately 2 cm. The blood supply to the gallbladder and common bile duct is derived from the left branch of the proper hepatic artery.\textsuperscript{19}

Bilirubin is a byproduct of the enzymatic cleavage of the heme molecule, a central structural element in the hemoglobin molecule of erythrocytes but also in thousands of ubiquitous cellular enzymes. Unconjugated bilirubin is a hydrophobic molecule but is soluble in plasma due to a strong affinity for albumin. After traveling to the liver, bilirubin is conjugated by the enzyme UDP-GT and is released into the bile caniliculi, eventually draining into the intestine at the major duodenal papilla. Bile salts are a natural detergent for the small intestine, binding endotoxin and bacteria and rendering them ineffective. Bile salts also are important in fat emulsification and absorption, which includes the fat-soluble vitamins. The majority of bilirubin is removed from the body as stercobilinogen in the feces while a smaller portion is removed as urobilinogen in the urine.

PATHOPHYSIOLOGY OF EHBT OBSTRUCTION

The effects of EHBT obstruction are widespread and devastating. When bile is retained due to EHBT obstruction, an accumulation of bilirubin in the blood occurs and down-regulation of the reticuloendothelial system (RES) soon follows.\textsuperscript{20,21} Lack of bile in the intestinal tract leads to diminished absorption of vitamin K in the ileum and, with time, vitamin K deficiency can lead to coagulopathies. Since factor VII has the shortest half-life of the routinely measured coagulation factors in dogs and cats, it would be expected that prothrombin time (PT) would commonly be elevated in animals with extrahepatic biliary tract obstruction; however, in many chronic cases of EHBT obstruction partial thromboplastin time (PTT) is also elevated and this finding is associated with a worse short-term outcome in dogs.\textsuperscript{4} Prolongation in PTT may be related to the binding of coagulation factors XI and XII by endotoxin. Endotoxia in the obstructive jaundice patient has been documented in humans and has been experimentally produced in multiple animal models.\textsuperscript{21–29} Development of sepsis is believed to be related to the lack of a detergent effect on bacteria and endotoxin within the lumen of the small intestine, allowing delivery of unbound bacteria and endotoxin to the liver and the already failing RES. Thus, through direct and indirect effects, EHBT obstruction can produce a variety of sequelae including acute tubular necrosis, hypotension, coagulopathy, decreased wound healing, gastrointestinal hemorrhage, systemic and portal endotoxia and bacteremia, continued gastrointestinal bacterial translocation, SIRS, sepsis, disseminated intravascular coagulation (DIC), and myocardial damage.\textsuperscript{23–27}
CLINICAL SIGNS OF EXTRAHEPATIC BILIARY TRACT DISEASE

Clinical signs in dogs and cats with extrahepatic biliary tract obstruction include decreased appetite and lethargy in up to 100% of patients, icterus in up to 100%, vomiting in up to 92%, weight loss in up to 82%, abdominal pain on palpation in up to 50%, and fever in 38%. The duration of clinical signs before presentation for surgery in dogs ranges from 2 hours to 210 days and 14 to 150 days in cats. Clinical signs associated with surgical complications of the biliary tree are nonspecific and mimic other abdominal disorders. Following surgery, development of abdominal pain, vomiting, anorexia, diarrhea, lethargy, icteric mucous membranes and serum, and signs of shock are all potential indicators of surgical complications that warrant further diagnostic investigations. Careful attention to daily physical examination findings in the perioperative period is an essential step in detecting complications.

COMPLICATIONS ASSOCIATED WITH A DELAY IN DEFINITIVE THERAPY

Delays in initiating definitive therapy for EHBT disease have been shown to significantly affect outcome in human patients. In the past, cholelithiasis in human beings was treated medically until the patient suffered from severe abdominal pain or when obstructive jaundice developed. Morbidity and mortality rates in human EHBT surgery were approximately 30% when surgical intervention was used as a last resort. Due to these poor success rates, the current surgical trend for patients with potential surgical EHBT disease is to provide an interventional, and often definitive, surgical therapy as soon as possible, and preferentially before the patient is systemically ill. The early use of cholecystectomy to treat human patients with nonobstructive cholelithiasis has significantly lowered the morbidity and mortality rates in humans undergoing EHBT surgery. Due to the influence of economics on provision of veterinary care, delays in providing definitive surgical care are also quite common in small animals with EHBT disease. Interestingly, use of surgery as a last resort has produced relatively high mortality rates in small animals, paralleling the historical results for this failed approach in human beings. Although there is no data to directly support the effects of early intervention in animals with EHBT disease, it would appear logical that adoption of this approach may show similar benefits in outcomes for animals.

Several recent publications have described the use of percutaneous biliary diversion in dogs with EHBT obstruction until the cause of the obstruction has resolved or until the patient is more stable for surgery. Although this strategy can be effective in lowering serum bilirubin concentrations and avoiding its sequelae, it does not address the physiologic consequences that are due to the absence of bile within the small intestine. Availability of interventional and laparoscopic techniques in human medicine produced a similar use of preoperative biliary drainage and decompression or definitive extracorporeal drainage. Unfortunately, most investigators concluded that preoperative biliary decompression and attempts at avoiding surgery for these diseases has led to prolonged hospitalization, increased morbidity, and, in some instances, a drastic increase in mortality. Although there are no current veterinary studies comparing preoperative decompression to early surgical intervention, it is the opinion of the author that early surgical intervention may provide a part of the solution to many of the complications associated with surgery of the EHBT.
**Surgical Complications**

The diseases that lead to a need for surgery of the extrahepatic biliary system in dogs are primarily acquired conditions and include extrahepatic biliary tract obstruction (EHBTO), gall bladder mucoceles, traumatic injury, and cholecystitis. The main goals of surgery are to confirm the underlying disease process, establish a patent biliary system, and minimize perioperative complications. Despite efforts to prevent them, a number of surgical complications do occur. General complications of biliary surgery will be discussed first, followed by specific sections on each of the more commonly performed procedures.

**PERIOPERATIVE HEMORRHAGE**

Hemorrhage is a frequent complication associated with biliary tract surgery. Common causes of hemorrhage include failure to ligate the cystic artery, ligature slippage, and iatrogenic damage to the liver parenchyma during gallbladder dissection for cholecystectomy. Avoidance of hemorrhage from the cystic artery is simply a matter of meticulous surgical technique. In small animals, bipolar electrocautery may be effective in coagulating this small vessel. In larger dogs, transfixation ligatures can be placed to achieve hemostasis without slippage. Hemorrhage from the surface of the liver is typically self-limiting but can be complicated by concurrent coagulopathies in patients with vitamin K deficiency. Please refer to the section on topical hemostatic agents used for hemostasis in the Complications of Liver Surgery chapter of this text.

**BILE DUCT OBSTRUCTION**

Postoperative bile duct obstruction can occur early or can be a latent problem. Early obstruction may occur secondary to intraoperative errors (inadvertent ligation of the bile duct, failure to recognize a source of obstruction at surgery), migrating sludge or hepatic duct choleliths not removed at surgery, or due to the development of postoperative pancreatitis. Latent obstructions are usually secondary to stricture formation at the site of previous surgery (eg, choledochotomy or choledochoenterostomy) or secondary to pancreatitis. In rare instances, recurrence of cholelithiasis may also result in latent postoperative bile duct obstruction. Cholecystectomy is recommended in animals with biliary stone disease to decrease the likelihood of recurrence. In animals that show evidence of continued or worsening icterus after biliary surgery, it is often difficult to discern whether the icterus is caused by an extrahepatic obstructive lesion, by the development of bile peritonitis, or by a primary hepatic parenchymal disease process. A variety of biochemical and imaging tests are used to determine a course of action when postoperative icterus is noted.

Bile duct obstruction causes an increase in total serum bilirubin with a corresponding bilirubinuria. Bilirubinuria may be the first sign of bile duct obstruction in dogs and may precede the development of jaundice because dogs have a low renal threshold for excretion of conjugated bilirubin and, with obstruction of the bile duct, renal excretion of bilirubin becomes important for elimination of the pigment. If the obstruction is complete, urobilinogen will be absent from the urine. Because its detection in urine is dependent upon many variables (exposure to light, drugs, sensitivity of detection methods) the absence of urobilinogen should be interpreted with caution. Changes in serum bile acid levels may be useful early in the disease but not as the disease progresses. Based on these considerations and the ready availability of serum bilirubin measurement in small animal practice, most veterinary surgeons will use simple determinations of serum bilirubin concentrations on serial samples (eg, every 24 to 48 hours) that are obtained after surgery. In animals that
show progressive elevation of serum bilirubin concentrations after surgery or in those that show no improvement in preoperative icterus, abdominal imaging is pursued.

As many as 50% of choleliths in dogs and cats are mineralized and, therefore, are radiopaque. In patients with radiopaque cholelithis, postoperative radiographs are recommended to document the successful removal of all stones from the extrahepatic biliary tract. Gas within the biliary structures and in the peritoneal cavity may complicate interpretation of radiographic imaging, depending on the surgery performed and the amount time that has passed since surgery. Ultrasound is a sensitive and specific indicator of the cause of bile duct obstruction in the preoperative and postoperative period. Choleliths are also readily identified with abdominal ultrasound. Abdominal ultrasound is currently the most useful and practical technique for demonstrating gallbladder and bile duct dilation associated with obstruction in small animals. Ultrasonographic findings of bile duct distention secondary to obstruction may be identified in up to 100% of cases involving dogs and cats. It is important to note that biliary obstruction may be diagnosed before the onset of clinical icterus with the use of abdominal ultrasonography and that minimal intrahepatic ductule distention is a subtle abnormality but is identified on ultrasound as early as 4 hours after experimental biliary occlusion. The absence of gallbladder dilation does not exclude EHBTO since the gallbladder may be ruptured or contracted due to inflammation (Fig. 1). The degree of biliary tract dilation in obstructed dogs is variable. Therefore, duct size would allow only a crude estimation of the duration of obstruction.

Although oral, intravenous, and cholangiographic contrast studies can be performed to investigate the etiology of biliary obstruction, they are rarely used in small animals. Unfortunately, high serum bilirubin concentrations, hypoalbuminemia, icterus, hepatocellular disease, pancreatitis, peritonitis, biliary obstruction, cholecystitis, or concurrent sulfonamide and salicylate administration cause decreased hepatic concentration of the contrast resulting in poor opacification of the extrahepatic biliary system.

Hepatobiliary scintigraphy in animals with hepatic and biliary disease has been used clinically in small animal patients with EHBK and may be a valuable diagnostic tool for differentiating postoperative extrahepatic biliary obstruction.

Fig. 1. Abdominal ultrasound of a dog with a contracted gallbladder, abdominal effusion, and free floating gallbladder mucocele (arrow) identified in the caudal abdomen.
from hepatocellular disease or damage. Various radiopharmaceutical agents have been used for hepatobiliary scintigraphy in both dogs and cats but most are derivatives of $^{99m}$Tc iminodiacetic acid (mebrofenin or diofenin). After intravenous injection, these compounds are excreted through the biliary system, then pass into the duodenum through the major duodenal papilla. Most reports have concluded that in dogs and cats if the intestines cannot be visualized within 3 hours of the injection of the agent it is generally considered likely that EHBO is present. The main disadvantage of scintigraphy is that it does not give accurate information as to the exact site or cause of obstruction, the patient must be housed in a radiation safe area until no longer radioactive (usually within 24 hours), and the test itself takes much longer to perform than most ultrasound exams of the biliary system.

When detected, postoperative bile duct obstruction will require surgical intervention to alleviate the source of obstruction. In rare instances, such as in dogs with postoperative pancreatitis and secondary biliary obstruction, a conservative approach may allow for spontaneous resolution of the obstruction.

**POSTOPERATIVE BILE PERITONITIS**

Bile peritonitis, or bilious ascites, is the inflammatory response of the peritoneum to the presence of bile. Postoperative bile peritonitis can be caused by dehiscence of a cholecystotomy incision, failure of cystic duct, bile duct, or hepatic duct ligatures, or anastomotic dehiscence of an incision in the biliary tract. Failure to identify and remove a diseased gallbladder or to recognize a damaged duct intraoperatively may also result in postoperative bile peritonitis. During cholecystoenterostomy it is possible to damage the cystic artery or twist the cystic duct leading to necrosis of the gallbladder wall or rupture of the cystic duct, respectively. If the bilirubin concentration of the abdominal effusion is greater than twice that of the serum concentration, it is diagnostic for bile peritonitis. There is a 27% to 45% survival rate for dogs with septic bile peritonitis and an 87% to 100% survival rate for dogs with sterile bile peritonitis. The onset of clinical signs in dogs with a ruptured biliary tract and the degree of peritonitis present are likely dependent on the volume of liquid bile, the concentration of bile salts, and the presence or absence of bacteria. Clinical signs include vomiting, anorexia, diarrhea, weight loss, icterus, abdominal distention, fever, and abdominal pain.

Bile salts are toxic to tissues and cause permeability changes and tissue necrosis that encourage the growth of bacteria. Sources of bacteria are thought to be endogenous anaerobic bacteria from the liver and intestine as well as hematogenous spread. Unconjugated bile acids are cytotoxic and induce tissue inflammation, altering the permeability of vascular structures within the peritoneal membranes. Transudation of fluid, and then transmural migration of enteric organisms into the peritoneal cavity, follows. Although virtually all bile acids derived from the biliary tree are conjugated, a bacterial infection or a low pH within the biliary tree will result in bile acid deconjugation. Postoperative bile peritonitis is fatal if left untreated and requires immediate surgical intervention. Goals of reoperation included identification and repair of the source of bile leakage, maintenance of a patent biliary tree, and copious abdominal lavage. Bacterial culture of abdominal fluid is useful in guiding postoperative antibiotic therapy and animals are placed on broad-spectrum intravenous antimicrobial therapy until results of culture and sensitivity return. The use of open or closed abdominal drainage is discussed elsewhere in this text (see Complications of Gastrointestinal Surgery).
COMPLICATIONS ASSOCIATED WITH GALLBLADDER SURGERY

In dogs and cats, a cholecystectomy is the most commonly performed surgery of the gall bladder in small animals and is preferred over a cholecystotomy because it decreases the likelihood of cholelith recurrence and avoids the need for a more technically demanding cholecystostomy closure. It has been our experience that the gallbladder wall does not seal well immediately after cholecystocentesis or following a cholecystotomy. There are few physiologic side effects of cholecystectomy, and although episodic abdominal pain and diarrhea associated with fat malabsorption have been described in human beings and induced in normal dogs and cats after undergoing cholecystectomy, this technique remains the standard of care for the treatment of cholelithiasis and gallbladder mucoceles in small animals. Complications of each procedure are described more specifically next.

Cholecystotomy

Cholecystotomy may be performed to obtain a full-thickness biopsy or mucosal cultures of the gallbladder, to explore the inside of the gallbladder and cystic duct, for removal of choleliths and sludge, for antegrade flushing and assessment of patency of the extrahepatic biliary ducts and for placement of a cholecystostomy tube. Complications of cholecystostomy include recurrence of cholelith formation, dehiscence of the incision, early or accidental dislodgement of a cholecystostomy tube, or obstruction of the cystic duct or bile duct with a blood clot. In most circumstances, there is no need to remove the gallbladder from the hepatic fossa when performing a cholecystotomy incision. If the surgeon prefers to dissect the gallbladder from the hepatic fossa, great care must be taken not to damage the cystic artery supplying the gallbladder as it branches from the left hepatic artery and is found immediately adjacent to the cystic duct.

Prevention of these complications is possible with careful attention to regional anatomy and adherence to surgical principles. Closure of a cholecystotomy incision is performed with a fine synthetic monofilament suture on a tapered needle in a simple continuous or inverting pattern. Some surgeons prefer a two-layer inverting closure but this is not necessary or recommended in most cases. Full thickness bites are recommended to assure that the submucosa is incorporated in the closure. A thorough local lavage of the gallbladder incision is performed and the omentum is placed over the incision.

Cholecystectomy

Indications for cholecystectomy include cholecystitis, cholelithiasis, gallbladder mucocele, gallbladder neoplasia, cystic artery infarction, or severe gallbladder trauma. Complications include bile leakage due to failure of cystic duct ligatures (3%–8%), hemorrhage secondary to failure of cystic artery ligations or from damage to the liver parenchyma during gallbladder dissection, and failure to document bile duct patency prior to cholecystectomy. Before performing a cholecystectomy, patency of the bile duct must be assured. This is done via a duodenotomy or from a cholecystotomy incision after removal of the gallbladder contents. Assessing the patency of the biliary tract after completing the cholecystectomy defeats the purpose as the lack of a patent system may indicate the need for a cholecystoenterostomy.

Hemorrhage from the hepatic fossa can be controlled with direct pressure applied to a lap sponge or by application of a hemostatic agent (Gelfoam or Surgicel). There is some reported risk of abscess formation using hemostatic agents in this area but the authors have not observed this clinically.
If a duodenotomy was used to assess patency of the biliary ducts, a small amount of sterile saline can be flushed gently into the common bile duct to assess the security of the ligatures placed on the cystic duct remnant. Aggressive flushing and excessive manipulation of a catheter in this area have led to rupture of the bile ducts and should be avoided.

**Laparoscopic Cholecystectomy**

In humans, laparoscopic cholecystectomy has been performed since the early 1980s and now represents the treatment of choice for gallstone disease and acute cholecystitis. Approximately 75% of all cholecystectomies are performed laparoscopically and almost all elective cholecystectomies are performed minimally invasively. This has proved to be a very safe method for cholecystectomy in human beings and has a very small percentage of conversion to open laparotomy. Surprisingly, the incidence of iatrogenic common bile duct injury in human surgery has increased by 0.5% to 1.5% during laparoscopic cholecystectomy compared to a traditional open approach.

Complications of laparoscopic cholecystectomy include those listed for open cholecystectomy and those that are specific to laparoscopy (see chapter on Complications of Minimally Invasive Surgery elsewhere in this text). If significant bile leakage, excessive hemorrhage or anesthetic complications occur, conversion to an open approach should be considered. Postoperative EHBO may be more likely to develop in animals undergoing laparoscopic cholecystectomy as a result of inadequate flushing of residual biliary sludge in the bile duct compared to patients undergoing open cholecystectomy, as it is more difficult to perform a complete exploratory of the biliary tract in patients undergoing laparoscopy. Avoidance of these latter complications is based on careful case selection. Laparoscopic cholecystectomy is not currently recommended in dogs with gallbladder mucocele or cholelithiasis that have preoperative evidence of EHBO.

**COMPLICATIONS ASSOCIATED WITH SURGERY OR INJURY OF THE EXTRAHEPATIC DUCTS**

*Ducts (Hepatic, Cystic, and Bile Duct)*

Unrecognized damage to the hepatic ducts, cystic, or bile duct during surgery leads to bile peritonitis and has potentially fatal complications. Similar consequences from dehiscence of a choledochotomy incision or failure of a cystic or hepatic duct ligature exist. Repair of ruptured hepatic ducts, the cystic duct, or bile duct can be performed, but is technically demanding and has a high rate of failure. There are well developed intrahepatic and extrahepatic communications between divisions of the liver that allow for collateral bile drainage. Given that dogs have between two and six extrahepatic ducts, sacrifice of one or more ducts can be performed without removing the liver lobe being drained by the affected duct. Choledochotomy is commonly performed in humans, especially when endoscopic retrograde cholangioscopy is unavailable or unsuccessful. Complications of choledochotomy in dogs and cats are mainly dehiscence and stricture formation. A recent report of choledochotomy and primary repair of ruptured biliary ducts in dogs and cats described successful outcome in 10 cases, with only one report of dehiscence and reoperation. Prevention of stricture formation in the postoperative choledochotomy is achieved by using a fine, monofilament, 4-0 to 6-0 suture in a simple interrupted or continuous pattern. An inverting or two-layer closure is avoided to prevent excessive narrowing of the luminal diameter. If the longitudinal incision is relatively short, it can be closed in a transverse direction to limit the narrowing of the luminal diameter. Omentum is wrapped around the closed incision. A closed suction
drain can be placed as a diagnostic aid to help detect early dehiscence of the choledochotomy. The drain is pulled in 3 to 5 days or when appropriate. A ruptured hepatic duct can be sacrificed as collateral drainage will develop in the dog. If a large tear or defect exists in the cystic duct, a cholecystectomy can be performed.

There is one report of a dog that underwent repair of the bile duct using commercially available porcine submucosa. Although this technique was not successful, many independent veterinary groups are currently evaluating other synthetics and biomaterials for definitive closure of bile duct tears, rents, and defects including fibrin glue, cyanoacrylates, jugular and splenic vein grafts, and serosa of local gastrointestinal tract.

**Choledochoduodenostomy**

Choledochoduodenostomy was first described in 1892 and is a commonly performed rerouting procedure in human patients. Because of the size of the canine common bile duct (3 mm), compared to the human bile duct (10 mm), it is significantly more challenging to perform a choledochoenteric anastomosis in dogs, increasing the risks of dehiscence or stricture formation. This procedure is performed using a routine end-to-side anastomosis or side-to-side anastomosis. In humans, this procedure is almost exclusively, performed laparoscopically. For the end-to-side anastomosis, the bile duct is ligated and transected as close to the duodenum as possible to limit the amount of tension on the anastomosis. Tension is a common cause of dehiscence, and because the sphincter mechanism is not routinely included in the anastomosis, enteric reflux into the bile duct is expected as another complication.

A side-to-side anastomosis can be performed as a sphincteroplasty technique or as a true side to side anastomosis. Dehiscence is avoided by limiting tension and using a fine monofilament suture material in a simple interrupted or continuous pattern. Omentum is brought to and wrapped around the surgical anastomosis following thorough lavage of the area. A closed suction drain can be placed as a diagnostic aid to help detect early dehiscence of the biliary enteric anastomosis. The drain is pulled in 3 to 5 days or when appropriate.

**COMPLICATIONS ASSOCIATED WITH BILIARY REROUTING PROCEDURES**

Biliary tract rerouting procedures are performed when bile duct obstructions are unable to be resolved intraoperatively, as an adjunct to removal of the proximal duodenum including the major duodenal papilla, and as a method to bypass a nonresectable malignant process involving the pancreas, bile duct, or proximal duodenum. Complications of biliary enteric anastomosis include dehiscence of the incision, stricture of the stoma, ascending cholangiohepatitis, and alterations to gastrointestinal physiology and digestion.

Cholecystoduodenostomy is currently accepted as the simplest and most physiologic technique to achieve biliary enteric anastomoses in dogs and cats. The procedure is performed using a mucosal appositional technique, creating a permanent stoma between the small bowel and the gallbladder. This can be done with hand suturing or with automatic stapling devices. To avoid intraoperative complications, the gallbladder must be in good health and the cystic artery must not be damaged during dissection and manipulation of the gallbladder out of the hepatic fossa. If cholecystoenterostomy is being performed because of bile duct rupture or secondary to proximal duodenal resection, it is imperative that the bile duct remnant staying in the body be ligated securely. If the rerouting procedure is being performed secondary to a blockage of the bile duct and there is little chance of the bile duct rupturing or leaking, ligation of the bile duct is not needed. When rerouting is being performed to
treat a temporary cause of obstruction (eg, pancreatitis), the bile duct should be preserved so that bile flow through the duct may be re-established and the rerouting procedure can be surgically reversed once the obstructive condition has resolved.

Chronic ascending cholangiohepatitis is a latent and common complication of biliary-enteric anastomosis. The most critical factor in creating a biliary-enteric anastomosis is providing a large enough opening to permit drainage of refluxed intestinal contents from the biliary tract back into the intestine. Numerous surgery texts recommend that the length of the cholecystoenterotomy opening should be 2.5 to 4 cm long to minimize stricture of the stoma and recurrent cholangitis associated with inadequate draining of refluxed intestinal contents. It is recommended to make a large stoma because contraction is expected to be about 50% of the original stoma size. The author has had success in creating an incision in the gallbladder extending from the fundus to the beginning of the cystic duct, with a corresponding incision in the intestine to minimize the effect of postoperative stoma contraction.

Several factors must be considered in selecting the enteral location for the biliary stoma. It is ideal to be as proximal in the small intestine as possible without creating tension on the biliary enteric anastomosis. This will allow for bile to enter the gastrointestinal tract as close to its normal anatomic location as possible without leading to dehiscence of the anastomosis. The surgeon must be careful not to damage, twist, or stretch the cystic artery or cystic duct when removing the gallbladder from the hepatic fossa or when the gallbladder is sutured to the intestine. In balancing the pros and cons of physiologic location against potential tension and damage of the cystic artery and cystic duct, many surgeons prefer to leave the gallbladder within the hepatic fossa or partially dissect it and perform a cholecystodudodenostomy, releasing the duodenocolic ligament will facilitate this technique.

The proposed section of bowel that will be used for the anastomosis is brought up to the gallbladder to make sure that there will not be too much tension. A full-thickness incision is made in the ventral surface of the gallbladder from the fundus to the beginning of the cystic duct at the infundibulum. A full-thickness longitudinal incision is made on the antimesenteric border of the small intestine the same length of the gallbladder incision. An absorbable, synthetic, monofilament suture, 3-0 to 5-0 is used in a simple continuous pattern to attach the gallbladder to the small intestine. Two separate suture lines are placed and the knots are made on the outside of the lumen. It is important to note that a common spot for leaking is where the knots of both suture lines come together at the oral and aboral ends of the anastomosis. Omentum is brought to and wrapped around the surgical anastomosis following thorough lavage of the area and abdomen. A closed suction drain can be placed as a diagnostic aid to help detect early dehiscence of the biliary enteric anastomosis. The drain is removed in 3 to 5 days or when appropriate.

The use of surgical stapling devices has also been described to accomplish a biliary-enteric anastomosis in dogs and cats, which may minimize some complications. The benefits of using a surgical stapling device for this procedure include minimizing the trauma and inflammation caused by multiple manipulations of the bowel, providing a rapid increase in tensile strength compared with sutured anastomoses. The use of stapling equipment also reduces surgical time. Bile duct anastomoses using titanium staples result in less fibrosis than sutured anastomoses, promote healing by primary intention and reduce the lag phase of healing.

Another alteration in gastrointestinal physiology that occurs with biliary-enteric anastomosis is ulcerative damage to the proximal duodenum. Cholecystojejunostomy may decrease the chances of enterobiliary reflux but increases the risk of peptic ulceration of the duodenum due to the altered physiology of the gastrointestinal tract.
Bile is a major source of $\text{HCO}_3^-$, which acts to neutralize gastric acid leaving the stomach and entering the duodenum. When bile is diverted from the duodenum to the jejunum via a rerouting procedure, fat digestion is decreased, gastric acid secretion is increased, and the neutralization of gastric acid in the duodenum is decreased. Duodenal ulcers may develop as a sequel and post-operative treatment with a proton-pump inhibitor is recommended. Owners should monitor for fever, inappetence, and vomiting, and seek veterinary assistance if these signs develop. Given the potential physiologic consequences of a distal cholecystoduodenostomy or a cholecystojejunoanastomosis in humans and small animals, other biliary-enteric anastomoses have been studied and described.

Other Biliary-Enteric Anastomoses (Roux-en-Y Cholecystojejunoanastomosis and Cholecystojejunoduodenostomy)

Cholecystojejunoanastomosis with isoperistaltic jejunal limb and cholecystojejunoanastomosis were developed in an attempt to minimize the negative effects on gastrointestinal physiology that occur with simple cholecystoenterostomy. Cholecystojejunoanastomosis with isoperistaltic jejunal limb (Roux-en-Y) is an alternative technique to cholecystojejunoanastomosis. This procedure involves creating an antireflux limb of jejunum to prevent ascension of jejunal contents into the extra and intrahepatic biliary system. Cholecystojejunoanastomosis uses three intestinal anastomoses to accomplish the most physiologic of the described biliary rerouting procedures. The interposed jejunal limb functions as a bile duct and an antireflux tube, allowing bile to be presented to the duodenum yet preventing intestinal contents from entering the extrahepatic or intrahepatic biliary tract. In humans, cholecystojejunoanastomosis (jejunal limb interposition) is the preferred technique for biliary re-routing, being associated with decreased enterobiliary reflux and less derangement in gastrointestinal physiology compared to the other types of cholecysto-enteric anastomosis. Historically, the veterinary literature has recommended against using any rerouting procedure that involves a Roux-en-Y limb because the isoperistaltic jejunal arm that is created to prevent intestinal reflux from entering the gallbladder needs to be at least 40 to 50 cm long in human beings. This has limited the clinical use of cholecystojejunoanastomosis in veterinary medicine because it is suspected that small dogs and cats will develop clinical short bowel syndrome after utilizing 40 to 50 cm of jejunum for this procedure. However, recent clinical experience in human patients has led to a trend of avoiding the use of such long segments of jejunum for the isoperistaltic limb, as longer limbs may lead to stagnant chime and small intestinal bacterial overgrowth. As an alternative to transecting the proximal jejunum, the distal duodenum can be transected and used to limit the amount of functional jejunum “lost” to the limb. These modifications may resolve concerns that have prevented the application of cholecystojejunoanastomosis in small animal patients, although the safety and efficacy of this procedure will need to be further evaluated before it is recommended in small animals with naturally occurring diseases. Thus, though there are a variety of theoretical physiologic advantages to application of cholecystojejunoanastomosis in dogs and cats, the simpler cholecystoduodenostomy technique is currently recommended as the standard of care.

Complications Associated with Placement of Biliary Stents and Tubes

Temporary biliary decompression can be accomplished using cholecystostomy tubes or choledochal stents in critically ill patients until they are stable enough for a more complicated procedure. However, preoperative decompression is controversial in humans, and in some studies has led to an increase in morbidity and mortality.
Percutaneous and laparoscopic methods for biliary tract drainage have been described in a small number of veterinary patients. Extracorporeal decompression and drainage of bile and its constituents in a patient with EHBO will facilitate the lowering of systemic bilirubin levels but will also eliminate the positive effects of enteral bile salts. As was discussed previously in this chapter, bile salts have a variety of important physiologic effects in the small intestine and biliary diversion may actually contribute to the systemic illnesses often observed in patients with EHBO.

Complications of choledochal stenting include obstruction of the stent, premature dislodgement or migration of the stent, ascending cholangiohepatitis, and severe local inflammation caused by the stent material. Choledochal stenting is frequently performed in humans to provide a conduit for bile flow into the duodenum across an area of obstruction or to provide support to maintain an open lumen in the face of ductal stricturing or malignant ingrowth. In dogs and cats, clinical scenarios where temporary reversible EHBT obstruction caused by pancreatitis and/or cholangiohepatitis are more frequently encountered. Candidates for stenting are those with functional EHBO (demonstrated by biochemical and imaging findings consistent with EHBO) in which a stent can be passed across the area of the obstruction. Treatment of traumatic common bile duct injury with subsequent bile leakage in addition to primary ductal repair can be supported by a choledochal stent, although it remains unclear in small animals whether stents are beneficial or detrimental to healing in these situations. Other indications for choledochal stenting may include palliation of malignancy and temporary drainage of the biliary system prior to definitive surgical repair in severely compromised animals.

Prior to considering choledochal stent placement, a thorough evaluation of the EHBT should be performed to evaluate for any evidence of biliary tract perforation, intraluminal or extraluminal masses or pancreatic abnormalities. An antimesenteric duodenotomy is performed over the anticipated location of the major duodenal papilla. A red rubber catheter of appropriate size (usually 3.5Fr to 5Fr for cats and 8Fr
to 12Fr for larger dogs) is used to catheterize the major duodenal papilla to assess patency of the duct. Care should be taken not to enter the pancreatic duct. This can occur especially in cats due to the conjoined nature of the ductal systems in this species. If passage of even a small catheter is impossible, choledochal stenting is not an option in that patient and a technique for biliary re-routing should be considered. The largest stent size that does not completely fill the common bile duct lumen should be chosen. Nonmetallic stents quickly become filled with dehydrated bile concretions and bile should be allowed to passively drain around the outside of the stent if needed. A report detailing the outcome in 13 dogs where choledochal stenting was used to treat a variety of causes of EHBO no EHBT re-obstructions occurred in those that survived the perioperative period. However, in a report of choledochal stenting in seven cats, two re-obstructed within 1 week of surgery. The small size of the catheter lumen used in cats may predispose to early re-obstruction. Care should therefore be taken using this technique in cats as morbidity in this species may be higher than in dogs. Spontaneous passage of the stent in the feces was documented in four of five dogs and two of three cats that survived to discharge and where the fate of the stent could be confirmed. In cases where the underlying pathology resolves (especially pancreatitis) stent removal by endoscopy 2 to 4 months postoperatively is advised due to the possibility for obstruction and ascending cholangiohepatitis. Endoscopic placement of choledochal stents using a side view endoscope has been evaluated in dogs and may hold promise for minimally invasive placement of choledochal stents in the future.

Cholecystostomy tubes provide temporary diversion of bile from the gallbladder to an extracorporeal closed collection system. Similarly to choledochal stenting, cholecystostomy tubes can be used to treat a temporary and reversible cause of EHBO without resulting in the long-term anatomical alteration to the EHBT that is associated with biliary re-routing procedures. Complications include early dislodgement and bile peritonitis, obstruction, and infection. Obstruction as early as 12 hours postoperatively has been described in a cat. Early dislodgement with subsequent intra-peritoneal bile leakage has also been reported. Despite some suggestions that 5 to 10 days is sufficient for catheter tract maturation and leakage prevention, recent evidence suggests that maintenance of the catheters for 3 to 4 weeks may be more appropriate. In some animals that are judged to be poor candidates for prolonged anesthesia, establishing temporary biliary drainage may be of value. If a feeding tube is in place, it may be possible to return the drained bile into the intestine through the tube, maintaining the physiologic fat absorption and endotoxin binding functions that are conveyed by bile salts in the intestinal lumen.

OTHER PERIOPERATIVE Complications

Excessive bleeding can occur following blunt dissection and retraction of the gallbladder from the hepatic fossa, particularly in dogs with bleeding diathesis secondary to vitamin K1 deficiency, DIC, coagulopathy, or primary hepatic disease. Assessments of coagulation factors and platelet deficiency or dysfunction should be performed preoperatively. In dogs with hemorrhage from the hepatic fossa, hemostatic agents can be placed in the fossa or an omental pedicle can be sutured over the area. In dogs with potential bleeding diathesis, freeing the gallbladder from the fossa can be partially or completely avoided, provided that a duodenal or jejunal loop can be anatomically positioned adjacent to the gallbladder and the biliary-enteric anastomosis successfully performed with minimal tension on the sutures.

Pancreatitis can result from excessive intraoperative traction and manipulation of the pancreas, which causes iatrogenic injury to the pancreatic parenchyma, ductal
system, or blood supply. The pancreas is also a target organ for ischemic damage resulting from systemic disturbances such as shock and sepsis. Thus, postoperative pancreatitis may be caused by serious systemic illness in some animals, rather than by direct manipulation of the pancreas.

PROGNOSIS FOR PATIENTS WITH EHBT SURGERY

Factors affecting prognosis in humans undergoing extrahepatic biliary tract surgery include malignancy, age (>60 years), fever, leukocytosis, azotemia, hypoalbuminemia, hyperbilirubinemia, anemia, and increased serum alkaline phosphatase (ALP).\(^{32,33}\) Humans and dogs\(^{112,113,116}\) with obstructive jaundice are at an increased risk of acute renal failure due to bacterial endotoxemia and the mortality rate for humans with obstructive jaundice is significantly higher in patients with acute renal failure than in those without renal failure.\(^{28,117}\) The absence of bile salts in the small intestine enables the absorption of endotoxin\(^{106,108,118}\) and gut-derived endotoxins are powerful renal vasoconstrictors, causing a decrease in intrarenal blood flow, a fall in glomerular filtration rate, and subsequent degeneration of the renal tubular epithelium.\(^{24–27,108,111–115}\)

In dogs and cats, many authors have evaluated risk factors associated with outcome in patients undergoing surgery of the EHBT.\(^{4,5,9,14–16}\) Factors besides renal azotemia, include the presence of septic bile peritonitis, dyspnea, leukocytosis, prolongation of partial thromboplastin time, hypotension, sepsis, and DIC. In general, when discussing prognosis associated with surgery in dogs and cats with extrahepatic biliary tract disease with the pet owner, a 20% to 40% and 40% to 60% mortality rate is given, respectively. However, cases in which an early diagnosis is made and surgical intervention is performed may have a much better prognosis.\(^{6,62}\) Based on the complex physiology associated with biliary disorders and the potential for such broad and devastating complications, it is clear that surgeons must use all available means to avoid the occurrence of these complications.

REFERENCES


