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Management of Extrahepatic Biliary Obstruction: A Role for Temporary Percutaneous Biliary Drainage

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Abstract: *Extrahepatic biliary obstruction (EHBO) is a life-threatening condition with several etiologies that leads to numerous systemic physiologic derangements. It often presents as an emergency condition and causes significant morbidity and mortality in small animals. Conventional treatment consists of corrective surgical procedures, frequently on an emergency basis, which have been associated with mortality rates of 28% to 64% in dogs. Mortality is exacerbated by prolonged anesthetic times. Cats with EHBO are at a similarly high risk for anesthetic and surgical complications, and their prognosis is considered guarded. To decrease mortality, attention must be focused on presurgical patient stabilization and integrated postoperative medical management strategies.*

Patients with extrahepatic biliary obstruction (EHBO) often require emergency surgical treatment. Transient biliary drainage is an important component of presurgical management that may improve outcomes in these patients by allowing normalization of systemic physiologic derangements. In some cases, biliary drainage may serve as definitive treatment for EHBO. Additional management strategies should be aimed at decreasing circulating bacterial toxins and normalizing intestinal mucosal barrier and liver functions. This article does not cover all aspects of critical care management of EHBO but rather focuses on some unique aspects of current concepts in management of this difficult condition.

Anatomy and Physiology of the Extrahepatic Biliary Tree

The extrahepatic biliary tree comprises the gallbladder, hepatic ducts, cystic duct, and common bile duct (CBD; **FIGURE 1**). The liver continuously produces bile, an important substance in dietary fat breakdown and toxin removal. Most bile is composed of bile acids synthesized from cholesterol. Bile production begins with conjugation of bile acids to bile salts by hepatocytes. Bile drains from microscopic canaliculi into larger ductules that unite and eventually form a few large hepatic ducts. Some hepatic ducts drain bile directly into the gallbladder, a pear-shaped organ with a rounded end (fundus) and a narrow neck that leads to the cystic duct.

Bile is stored and concentrated in the gallbladder. In dogs, the gallbladder is positioned within the liver, bordered laterally by the right medial lobe and medially by the quadrate lobe; in cats, it is positioned more superficially. Bile from the gallbladder is delivered in surges to the cystic duct, stimulated primarily by cholecystokinin, a hormone induced by the presence of food in the duodenum. The bile is then transported to the CBD and eventually into the duodenum.

The terminal portion of the canine CBD enters the dorsal or mesenteric wall of the duodenum, where it is closely associated with pancreatic tissue. Thus, pancreatic swelling in this area can result in duct obstruction. The anatomic relation of the CBD to the pancreatic ducts varies, particularly in cats. The canine CBD most commonly unites with the minor pancreatic duct at the papilla before draining into the duodenum (**FIGURE 2**). This union forms the major duodenal papilla, which empties a few centimeters distal to the pylorus.[1] In cats, the CBD most commonly joins the major pancreatic duct before entering the duodenum.[2] In the presence of intestinal or hepatic disease, this ductal fusion results in an increased risk for ascending infection and ensuing infectious or biliary pancreatitis.[2,3]

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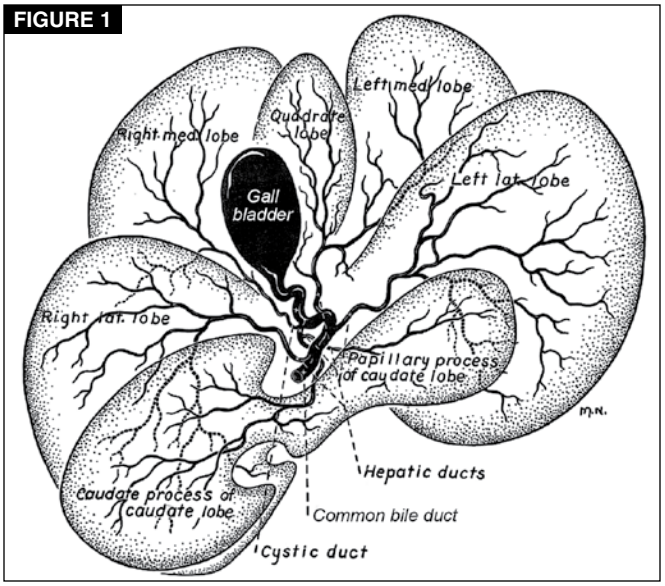
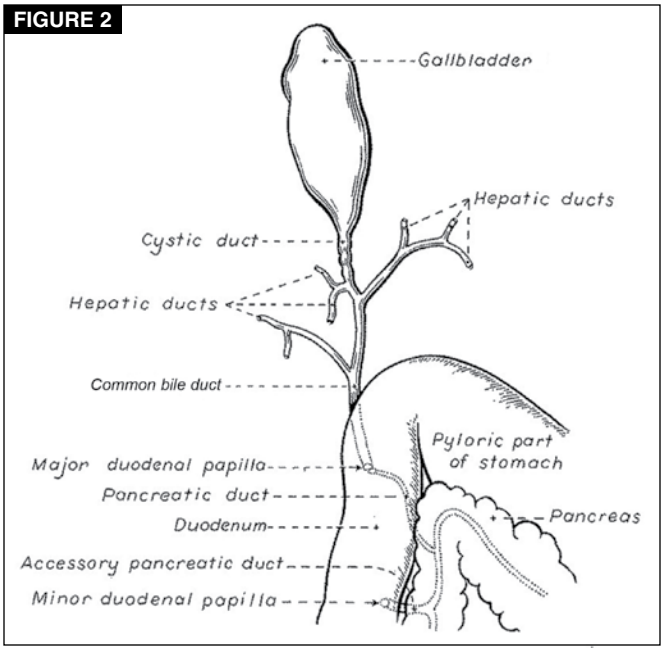
FIGURE 1



Schematic of the biliary anatomy of the dog. Reprinted with permission from Evans HE, ed. ***Miller's Anatomy of the Dog***. 3rd ed. Philadelphia: WB Saunders; 1993.

FIGURE 2



Schematic drawing showing the relationship of the CBD and the major pancreatic duct in the dog. Reprinted with permission from Evans HE, ed. ***Miller's Anatomy of the Dog***. 3rd ed. Philadelphia: WB Saunders; 1993.

About 95% of bile acids are absorbed into the blood in the ileum and from the blood back into the liver. The reabsorbed bile acids are recycled and resecreted into the canaliculi as bile salts. In a healthy animal, few to no bile acids are found in blood.[4]

Etiologies of Extrahepatic Biliary Obstruction

When biliary drainage from the gallbladder is impaired, bile becomes inspissated or sludge-like. Biliary sludge is seen as thick bile during surgery and can vary from a highly viscid fluid to a semisolid material. It is often mixed in consistency and may resemble tar. On ultrasonography, biliary sludge is seen as an echogenic substance in the gallbladder that may exhibit gravity dependence. Biliary sludge may be an incidental finding on ultrasonography but is often seen in the presence of a distended and tortuous CBD and, sometimes, a distended gallbladder.[5,6] This highly viscous sludge can result in CBD obstruction or exacerbate the effects of a partial CBD obstruction.[4,7–9] In our clinical experience, solidified biliary sludge is often found lodged at the sphincter of Oddi and, when dislodged, allows biliary drainage. This observation may suggest a pathogenesis of waxing and waning signs of biliary obstruction with transient obstruction by fragments of bile sludge.

EHBO in dogs and cats can be caused by either intraluminal CBD pathology or extraluminal abnormalities resulting in CBD compression. Extraluminal causes of EHBO are more common in dogs than in cats, with pancreatic disease the leading cause.[1] Other extraluminal causes include neoplasms (pancreatic, duodenal, pyloric, hepatic, biliary), diaphragmatic hernias, and congenital abnormalities.[1,5,10,11] Less commonly implicated intraluminal causes of obstruction include cholelithiasis (choleliths in the gallbladder), choledocholithiasis (choleliths in the bile duct), and inspissated bile (biliary sludge).[1,8,9]

Cats are susceptible to the same etiologies of EHBO as dogs; however, the leading causes are not well established. In cats, intestinal or hepatic disease increases the risk for pancreatitis caused by an ascending infection.[2,3] One study found the causes of feline EHBO to generally be either inflammatory diseases such as pancreatitis, cholangiohepatitis, cholecystitis, and cholelithiasis or neoplasia of the biliary tree or pancreas.[2] The authors of this study suggested cholangiohepatitis as the primary etiology of feline EHBO.[2]

Physiology of Biliary Obstruction

Biliary obstruction results in decreased ability of the liver to recirculate bile salts. Bile salts aid in intestinal absorption of lipids and the fat-soluble vitamins A, D, E, and K. Deficiency of vitamin K, a key component in the physiology of coagulation, can lead to coagulation deficiencies. These coagulation deficiencies are evidenced by increased partial thromboplastin time,[4,12] prolonged activated clotting time, protracted one-stage prothrombin time (OSPT), and prolonged activated partial thromboplastin time (APTT) in dogs with EHBO.[13] Likewise, prolonged OSPT and APTT were documented in a recent study of EHBO in cats.[14]

Obstruction of the biliary tree results in a reduced ability to conjugate bile acids, leading to increased amounts of circulating unconjugated bile acids. The rate at which these substances accumulate in the blood depends on the degree

of obstruction (complete or partial) and the compliance of the gallbladder and biliary tree. Serum bilirubin levels are often used as a surrogate test of this system. Normally, the gallbladder and biliary tree can stretch to accommodate an increased volume of retained bile. However, this compliance is limited. As expansion progresses, the pressure within the biliary system reaches a point at which the liver is unable to excrete bile into the canaliculi, and bile acids accumulate in the blood. In dogs, the maximal bile secretory pressure the liver can achieve is 30 to 35 cm H_2O.[15] Reduced biliary system compliance due to inflammation (acute or chronic) or scarring may result in a more rapid onset of icterus and systemic signs associated with EHBO. In the worst-case scenario, gallbladder necrosis or rupture can occur due to pressure-induced ischemia.

Unconjugated bile acids are cytotoxic to the intestinal mucosa. High levels of circulating unconjugated bile acids lead to intestinal tissue inflammation and necrosis and increased intestinal mucosal permeability.[4] Inflammation and altered blood flow to the acinus and hepatocytes are major components of hepatocyte injury due to intrahepatic cholestasis.[15] Subsequently, enteric organisms and/or their toxic by-products are more easily able to translocate across the intestinal mucosal barrier, and endotoxemia ensues. At the same time, decreased amounts of circulating bile salts in the intestinal lumen reduce micelle formation, further promoting intestinal bacterial overgrowth and exacerbating bacterial endotoxemia.

Biliary obstruction has also been shown to cause decreased liver bacterial clearance due to alterations in the hepatic reticuloendothelial system (RES) and Kupffer cell function.[16,17] A study[16] demonstrated that Kupffer cell phagocytosis increases in the presence of biliary obstruction in mice; however, vital killing mechanisms are impaired, as evidenced by increased numbers of live bacteria recovered from lysed Kupffer cells. One study in rats revealed that up to 30% of bacteria may survive within the Kupffer cells of patients with biliary obstruction and subsequently can be transported to the mesenteric lymph nodes and beyond, spreading infectious agents to multiple organs.[17]

Another consequence of biliary obstruction is an increased sensitivity to endotoxin exposure due to alterations in the RES. In mice with biliary obstruction, tumor necrosis factor α is secreted in increased amounts from Kupffer cells, leading to a marked proinflammatory response to endotoxin.[16] This effect, combined with increased absorption of endotoxin, leads to significant deleterious systemic effects in dogs and cats with EHBO.

Clinical Signs

Clinical signs in the initial stages of canine EHBO are typically nonspecific, and most dogs do not present until they are icteric.[4] If the obstruction is partial, the signs may wax and wane for several weeks. Consequently, the time from onset of noted clinical signs to surgical correction has been documented to range between 7 to 120 days, with a median duration of 14 days in dogs.[18] In a study in cats,[3] the median time from the onset of signs to examination was 24 days. The variable onset of signs may be attributable to individual variation in the compliance of the biliary system, whether the obstruction is complete or partial, and whether aggregates of bile sludge are intermittently obstructing the CBD. In animals with intermittent obstruction, increased intraluminal pressure may occasionally force enough bile sludge through the terminal sphincter region of the CBD and into the duodenum to transiently clear the biliary system.

As biliary obstruction progresses, dogs and cats are often lethargic and may have weight loss, anorexia, and a history of vomiting or diarrhea. A recent study documented anorexia and vomiting as the most common clinical signs reported in dogs.[4,19] A study of EHBO in cats found that more than 80% were icteric, lethargic, and anorexic and had lost weight.[2,14] The generic nature of these clinical signs may make EHBO difficult to diagnose. Other signs, such as abdominal pain and distention, may mimic other abdominal pathologies.

Diagnosis

Most animals with EHBO are icteric at presentation, with serum bilirubin values >2.5 mg/dL.[7] Early diagnosis of EHBO may be challenging because clinical signs and hematologic abnormalities often follow the onset of obstruction by weeks to months.[6] Elevated liver enzyme values are common in dogs and cats with EHBO due to liver damage or disease but are not specific for biliary obstruction. Increased alkaline phosphatase (ALP) and γ-glutamyltransferase (GGT) levels are typical in cases of cholestasis.

In dogs and cats, bilirubinuria may be the first abnormality noticed.[3,4] An experimental study in dogs with acute EHBO demonstrated an initial increase in serum ALP and bilirubin.[20] All dogs in another study had increased ALP values, and most also had increased values of AST, ALT, GGT, and serum bilirubin.[21] Cats may have similar increases in liver enzymes. Multiple studies have demonstrated corresponding increases in ALP, ALT, AST, GGT, and serum bilirubin in cats with biliary obstruction.[2,3,14] A study of cats with EHBO found hyperbilirubinemia to be present in all cases.[2] Another early and sensitive marker of liver dysfunction that may reflect EHBO is an increased level of serum bile acids.

Differentiating primary cholestatic disease processes from EHBO is important because surgical drainage procedures do not benefit and may harm patients with primary intrahepatic cholestasis. Detection of a distended gallbladder or bile ducts with increased tortuosity provides strong support for mechanical obstruction of biliary outflow and can justify

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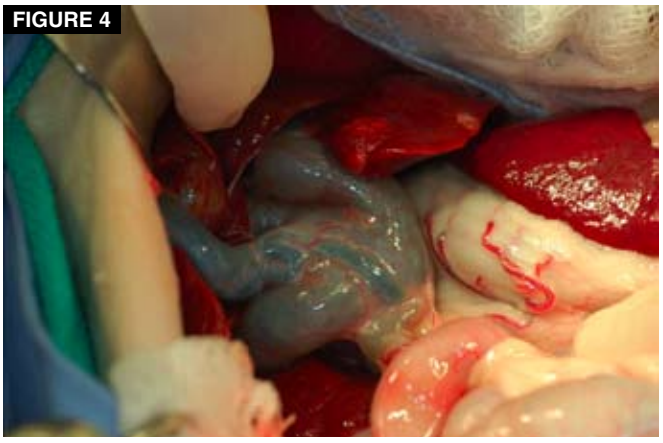
FIGURE 3

Grossly distended gallbladder seen during surgery for EHBO.

FIGURE 4



Distended and tortuous CBD, cystic duct, and hepatic ducts due to chronic EHBO.

surgical intervention (**FIGURES 3** and **4**). Imaging studies are most appropriate for detecting these changes. Abdominal radiography may yield a diagnosis of hepatomegaly,[2–4] gallbladder distention, and mineralized cholecystic calculi,[2,22] of which approximately 14% to 50% are radiopaque.[22] Abdominal ultrasonography can be sensitive and specific for evaluation of EHBO,[23] demonstrating tortuous bile ducts and/or an enlarged gallbladder, and may be one of the most useful tests that can be performed without general anesthesia. In one study, ultrasonography showed all cats with EHBO to have an enlarged gallbladder filled with echogenic bile sludge.[14] Another study using abdominal ultrasonography in cats with EHBO found abnormalities suggestive of EHBO in all animals.[3] A contrast cholecystogram may also be useful in confirming and localizing CBD obstruction; however, because this test can be time consuming and the secretory capability of the liver into the biliary system may be compromised, this study may be of more value in determining the site of biliary obstruction after biliary drainage using a percutaneous catheter has been established.

Treatment and Prognosis

Emergency Surgical Treatment

Emergency treatment of a blocked CBD requires reestablishment of bile drainage. Continued obstruction of the biliary system will result in progressive physiologic derangement and, ultimately, death. Currently, emergency surgical intervention with removal of an obstructing cholelith or performance of a primary biliary rerouting procedure, such as a cholecystoenterostomy or choledochoenterostomy, is the most common treatment. However, such procedures are complex and technically demanding, particularly with respect to manipulation of acutely inflamed tissues, and patients may have altered coagulation states and be prone to decompensation under prolonged general anesthesia.[3,12,19,21] These surgeries are lengthy, and it is common for patients to begin to fail under anesthesia before completion. In cats with EHBO, significant hypotension, a component linked to greater surgical mortality, has been described after 60 to 90 minutes of general anesthesia.[2,3] For these reasons, alternative approaches to definitive treatment have been explored, including the placement of stents or tubes within the CBD via open laparotomy or endoscopically. Biliary surgical procedures may also be combined with cholecystectomy, depending on the cause of the obstruction. However, the risk inherent in performing definitive surgery under emergency conditions for EHBO is substantial. Despite improvements and advancements in surgical technique and perioperative supportive care, high surgical mortality is reported.[2,10–12,22,24] Overall perioperative mortality rates of 28% to 64% have been reported in dogs undergoing emergency surgery for EHBO,[10–12,22,24] and some patients, particularly animals with evidence of systemic toxicity and decompensation, are at even greater risk for mortality in the acute postoperative period. In one study,[12] mortality in dogs with coagulopathies at the time of surgery, as evidenced by increased partial thromboplastin time, was as high as 73%. Similarly, only 30% of dogs with elevated serum creatinine values survived after surgery. The presence of septic bile peritonitis and profound hypotension during and after surgery were also poor prognostic indicators.[12,19]

Preoperative Drainage and Patient Stabilization

The very high mortality rates in animals treated for EHBO by conventional emergency surgical approaches have stimulated a search for alternative strategies for treatment of this difficult condition. The primary goals of these approaches should be to (1) reduce surgical tissue handling and trauma, particularly in the acute phase of the condition; (2) shorten general anesthetic times during the critical care period; and (3) allow normalization of systemic physiologic derangements before subjecting the patient to a more involved surgical procedure. Ideally, such an approach would, in some cases, supplant the need for more complex surgical procedures.

Temporary Biliary Drainage for Patient Stabilization

Temporary biliary drainage has been used to avoid the negative aspects of emergency biliary rerouting procedures but has not yet achieved widespread acceptance in veterinary surgery. Biliary drainage allows recovery and normalization of the patient before an involved definitive surgical repair and has the potential to substantially lower surgical mortality.[18,25–27] Evidence of improved homeostasis is frequently seen within 24 to 48 hours of reestablishing biliary drainage.[25,28] Experimental studies in dogs and rodents demonstrate improvements in RES function, decreased liver enzyme values, and reduced serum bilirubin, reflecting improved liver function.[25,26,29,30] Most patients also display rapid improvements in clinical signs, with increased eating and drinking,[28] allowing for improved nutritional and coagulation status. Increased eating and drinking can also help normalize the intestinal barrier function when combined with management strategies such as administration of oral lactulose, early enteral feedings, and bile replacement through orogastric feedings.[13,27,31–35]

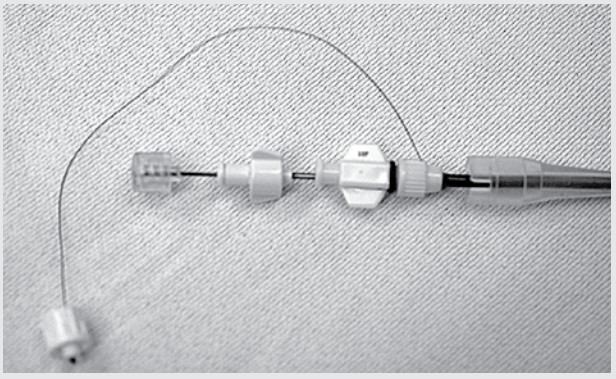
Furthermore, when biliary obstruction is due to a resolvable pathology such as inflammatory swelling around the CBD, temporary provision of bile drainage until the obstructive swelling has resolved may serve as definitive therapy and negate the need for surgical correction. Previous reports have described cases in which pancreatitis-mediated EHBO resolved after biliary drainage without surgery to the biliary tree.[11,12,19,36] Biliary drainage may also help reduce stasis and sludge formation by decreasing intraductal pressure, thereby facilitating restoration of gallbladder contractions. The ideal method of transient biliary drainage should be accomplished with minimal trauma and anesthetic time. Current methods of providing temporary biliary drainage include stent or tube placement in the CBD, percutaneous needle aspiration of the gallbladder, and temporary percutaneous cholecystostomy (PC) catheter insertion.

Stenting the CBD using manufactured wire stents or rubber tubes, with or without suture fixation, can be considered a means of temporary provision of biliary drainage because the tubes are usually extruded from the bile duct after some time and excreted in the feces.[4,14,21] In some cases, however, wire stents may be permanently retained within the CBD. CBD stenting is currently done via an open laparotomy and enterotomy to expose the duodenal papilla and insert the stent. This technique allows accurate placement with minimal bile leakage. However, it requires a significant surgical intervention and protracted anesthetic time, which are not optimal for a compromised patient. In one retrospective study of 13 dogs with EHBO managed by stent placement, the average anesthetic duration was 3 hours and 30 minutes,[21] substantially longer than the 60 to 90 minutes typically described as a window of relative anesthetic stability in these cases. Thus, two of the major advantages sought in provision of temporary biliary drainage—avoidance of extensive surgery and long general anesthesia—were not achieved. The primary advantage of this approach, if successful, would be elimination of the need for cholecystoenterostomy and follow-up surgery. Efforts have been made to attempt to place CBD stents via endoscopy, but the technical challenges of this approach make it unlikely to be widely applicable in small animals.

Percutaneous needle aspiration of the gallbladder can provide rapid, transient biliary decompression and drainage with a minimal need for general anesthesia.[37] However, frequent use of this method is inadvisable, and thus it is

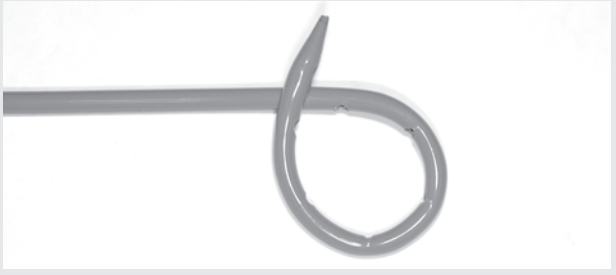
FIGURE 5

Percutaneous biliary drainage catheter with integral trocar (Abscession catheter, Angiodynamics, Queensbury, NY). Reprinted with permission from Murphy SM, Rodriguez D, McAnulty JF. Minimally invasive cholecystostomy catheter placement for management of extrahepatic biliary obstruction in animals. *Vet Surg* 2007;36:675-683.



The hub of the catheter has a device for creating a locking loop after removal of the integral trocar.

The trocar can be seen in the catheter tip.



Loop formed after removal of the trocar and tightening of the attached cord.

not suitable for biliary drainage over the period of time necessary to stabilize and normalize an EHBO patient. It is unclear whether percutaneous needle aspiration provides tangible benefits in managing EHBO.

PC catheter placement is currently the least invasive and most effective method for providing biliary drainage over a prolonged period. PC catheters can be left in place for weeks to months with a relatively low risk of biliary leakage and can be used to perform contrast cholangiography to determine the site of biliary obstruction and document resolution of the obstruction. These catheters can also be used for gallbladder flushing to help prevent bile dehydration and sludge formation during management of EHBO patients.

A variety of catheters may be used for cholecystostomy. The most convenient are manufactured for direct placement and have an integral trocar and locking mechanism to hold them in place once inserted. However, it is also feasible to use a Foley catheter with a purse-string suture placed via a minilaparotomy incision if locking trocar catheters (e.g., Abscession, Angiodynamics, Queensbury, NY) are not readily available (**FIGURE 5**).

Laparoscopy-assisted or ultrasound-guided PC catheterization is well described in humans for management of EHBO. However, ultrasound-guided methods used in humans have not met with consistent success in veterinary patients, most likely due to the substantial differences in anatomic conformation between animals and people. Studies on cadaver dogs have demonstrated that a transhepatic approach is not advisable because of a high incidence of penetration of the pleural space.[28] Additionally, ultrasound-guided PC catheterization is not recommended because it is often unsuccessful and the risk of bile leakage from the site of attempted gallbladder penetration is increased. Laparoscopy-assisted PC catheterization via a transperitoneal route is recommended, based on the high success rate documented, shorter anesthetic time, minimal tissue trauma, minimal chance of bile leakage, and ability to visualize the gallbladder. Laparoscopic assistance allows direct visualization of the gallbladder and the ability to grasp it to facilitate catheter insertion. If catheter insertion fails on the first attempt, laparoscopy permits the catheter to be reinserted through the initial puncture site in the gallbladder, decreasing the risk of bile leakage. Case examples illustrate that catheter placement is relatively fast and successful.[28]

Selection of Patients for Percutaneous Cholecystostomy Catheterization

There are conflicting reports in the human literature on the benefits of minimally invasive presurgical biliary drainage via PC. In several reports,[31,38,39] PC reduced morbidity and mortality rates in human patients with acute cholecystitis and served as definitive therapy in 24% to 52% of patients. However, other studies[5,40–43] have demonstrated no advantage or decrease in patient mortality associated with presurgical biliary drainage versus surgery alone. This controversy should be extrapolated to animals with caution, particularly because the mortality rate in treatment of acute biliary obstruction in people averages between 3.7% and 9%, which is substantially lower than the 28% to 64% mortality reported for veterinary patients. In veterinary medicine, the extremely high mortality associated with emergency surgical correction of this condition provides a powerful argument that veterinarians are faced with a uniquely lethal condition and supports exploration of this alternative approach to attempt to improve outcomes.

Some veterinary patients do survive emergency biliary rerouting surgery without presurgical biliary drainage. Thus, there are insufficient data to indicate which patients would best benefit from a temporary drainage procedure. In the past, temporary drainage was often only applied to patients that were unable to tolerate anesthesia and, under those conditions, achieved predictably poor results.[10] Improved outcomes have been seen with a more generic application of the method.[28] In the absence of an extensive clinical database that would allow subdivision of patients into preferred treatment categories based on known risk factors, there remain two potential approaches to application of percutaneous biliary drainage in veterinary patients. The first is to temporarily drain all acute EHBO cases for a minimum of 24 to 48 hours before definitive surgery and use the accrued clinical experience to refine the approach. This approach would likely establish a minimum baseline mortality for this condition but would subject some patients to an unneeded drainage procedure. The second is to consider establishing objective criteria for application of transient drainage, based on factors that are known to relate to mortality or that might play a physiologic role in mortality. These criteria could be adjusted as clinical experience is accrued.

Two factors that play a large role in mortality of EHBO patients are the chronicity of the biliary obstruction and the acuteness of systemic toxicity. These factors may be useful as indications for presurgical drainage. δ-Bilirubin, the fraction of bilirubin that is covalently bound to albumin, may be useful in assessing chronicity. In dogs, serum bilirubin and δ-bilirubin levels increase at different rates after biliary obstruction: serum bilirubin levels increase rapidly[34,35] and then plateau within a few days,[6] whereas δ-bilirubin levels gradually increase over the duration of biliary obstruction.[44] Levels of δ-bilirubin also decline more slowly than those of unbound bilirubin. Of clinical importance, the concentration and proportion of δ-bilirubin have been found to correlate with the duration of biliary obstruction; therefore, this measurement may be useful in assessing the need for presurgical drainage in dogs.[44] In an experimental study in dogs, δ-bilirubin levels were 29% and 43% of total bilirubin at 4 and 11 days of EHBO, respectively.[44] Based on

studies in humans, management of acute obstruction with PC drainage would be expected to more rapidly reduce serum bilirubin levels and improve postoperative morbidity and mortality rates compared with surgical drainage.[43,45] However, in cases of prolonged obstruction where there is increased likelihood of hepatocellular damage, serum bilirubin levels drop more slowly due to the higher percentage of δ-bilirubin present in the serum. Further research is needed in veterinary patients to ascertain the relation between clinical decision making and mortality related to chronicity when presurgical biliary drainage and assessments aided by δ-bilirubin measurements are used.

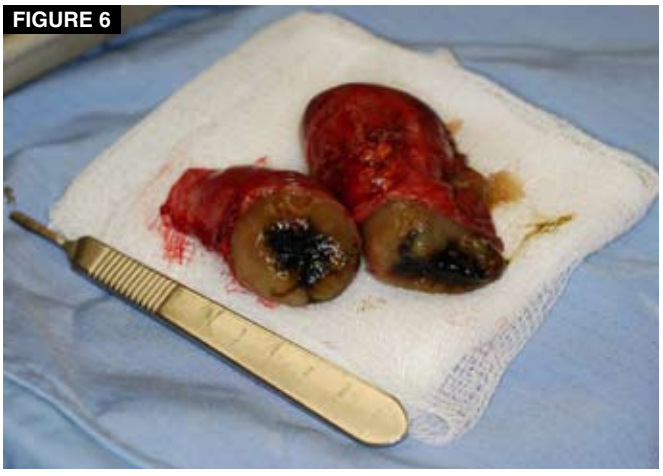
Other factors relating to acute systemic toxicity that may be valuable in deciding when to consider presurgical biliary drainage include the coagulation status and serum creatinine level of the patient. These measurements have been shown to be highly correlated with mortality and thus may be indicators for more effective patient stabilization before definitive surgery. However, in case series that have documented the relation of coagulopathy or increased creatinine level to mortality, patients continued to have a high rate of postoperative mortality even in the absence of these factors.[12]

Another factor to consider in placement of a PC catheter is whether a biliary mucocele is present and, if so, what portion of the biliary tree it affects. Mucoceles, seen in dogs and cats, may be isolated in the gallbladder or may extend down the cystic duct to the CBD.[45] Mucoceles can be incidental findings or may be associated with bile sludge viscid enough to cause CBD obstruction (**FIGURE 6**). When a mucocele can be bypassed or penetrated to access the zone of bile sludge with the gallbladder, a temporary drainage catheter may prove to be effective. However, mucoceles that fill the gallbladder or cystic duct may prevent effective functioning and, therefore, use of a drainage catheter.

Management of Percutaneous Cholecystostomy Catheters

Placement of a biliary drainage catheter should be combined with an appropriate management regimen to maximize its benefits. Management protocols for PC catheters in animals continue to evolve. One potential risk is blockage of the catheter by biliary sludge or mucus plugs.[9] We recommend that catheters be flushed and aspirated every 4 to 6 hours in the first several days after placement to maintain patency and assist in liquefying dehydrated bile sludge. This practice has been shown to be moderately successful in dissolving thick biliary sludge and maintaining patency. In one study, catheter flushing using a heparinized saline solution to prevent obstruction demonstrated 86% success in people[46]; however, another study in people demonstrated no efficacy of heparinized saline flushing.[47] This discrepancy is most likely attributable to the composition of the catheter obstruction. Specialized solutions designed to dissolve bile sludge have shown some success in people[48] but have not been tested in animals with EHBO.

FIGURE 6



Biliary mucocele in a dog. The entire inner surface of the fundus of the gallbladder is covered by a thick epithelial layer and organized mucin. The central cavity was filled with biliary sludge that was flushed into the CBD. Such a situation may be amenable to temporary catheter drainage if the cystic duct is not obstructed. However, it may be difficult to make this determination before catheter placement, and adequate drainage may not be possible. If establishment of CBD drainage is in question after catheter placement, contrast cholangiography can be performed via the catheter.

Another potential risk of maintaining an indwelling PC catheter is the development of infection. It is postulated that the risk of contracting an ascending infection increases with the placement of a cholecystotomy catheter. However, bacterial organisms in the bile are not reported to affect surgical outcome, so the overall risk to the patient appears to be low.[12,19,28] Studies indicate that 39% to 81% of dogs undergoing extrahepatic biliary surgery have positive bile cultures before catheter placement.[3,10,12,14,19,28,49] An experimental study also suggests that laparoscopy-guided transperitoneal catheter placement may have a decreased risk of ascending infection compared with ultrasound-guided catheter placement.[28]

Although low, the risk of bile leakage with catheter placement must be considered, as bile is caustic and, if bacteria are present, lethal septic bile peritonitis is possible. Tapered trocar catheters are not prone to leakage but could leak if they became obstructed and were able to generate sufficient intrabiliary pressure. However, in experimental CBD ligation in normal dogs, the maximum pressures measured within the gallbladder were less than or equal to 25 cm H_2O.[50] A study comparing the leakage potential of PC catheters placed transperitoneally by laparoscopy found that all catheters were able to withstand 25 cm of H_2O pressure for 5 minutes without any indication of leakage.[36] In another study, the maximum pressure against which the liver could secrete bile into the biliary system was 30 to 35 cm H_2O,[50] a pressure that all PC catheters but one were able to withstand

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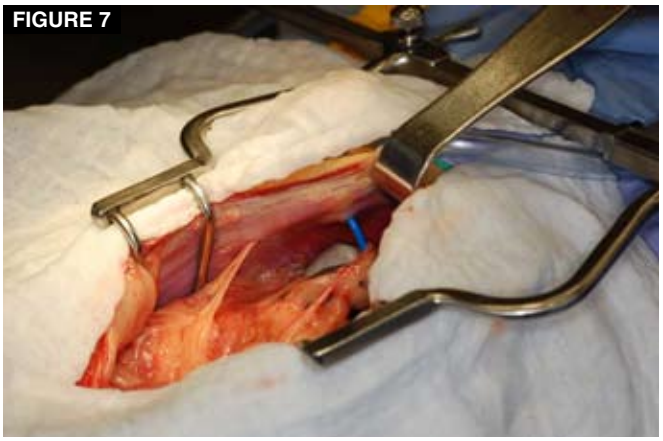
FIGURE 7



Incomplete tract formation 10 days after catheter placement. In this dog, the catheter was removed and the gallbladder closed after EHBO (due to pancreatitis) had resolved. The catheter can be seen traversing from the body wall to the gallbladder. Formation of a sealed tract around the catheter is incomplete. A much longer catheter residence time would be needed if catheter removal without further surgery was desired.

without leakage.[28] Thus, PC catheters appear to present a very low risk of bile leakage into the peritoneal cavity, both from the standpoint of the proven pressures these catheters can withstand and from our clinical experience. We have not observed bile leakage with PC catheter use unless the catheter was removed prematurely.

When pancreatitis or other inflammatory swelling is the source of EHBO, resolution of the swelling may eliminate the need for further surgical intervention. This can be confirmed by contrast cholangiography using the PC catheter. In such cases, the PC catheter should not be removed before the development of a mature fibrous fistulous tract. Premature catheter removal may result in later rupture of a weak catheter tract, resulting in intraabdominal bile leakage. Therefore, catheters must be maintained for adequate tract development and maturation to occur if removal without further surgery is contemplated (**FIGURE 7**). If the CBD is patent, these catheters can be capped and covered by a bandage during this period. Current published veterinary recommendations[51,52] suggest removal after 5 to 10 days; however, in one case,[28] this was an insufficient amount of time and bile leakage resulted. In humans, only 13% of transperitoneal tracts are mature enough for safe catheter removal at 14 days.[31] Our recommendation is for catheters to be left in place at least 21 to 28 days before removal. Even longer catheter residence for tract maturation should be considered if the animal has a condition that may delay wound healing, such as diabetes mellitus, severe malnutrition, steroid therapy, or chronic renal failure. In animals, maintaining PC catheters for a long time may be challenging, and it may be preferable to perform a surgical takedown of the catheter via a minilaparotomy or laparoscopy and to close the entry hole into the gallbladder with one or two sutures.

Integrated Management of the EHBO Patient

Reestablishment of biliary drainage through a PC catheter is only one aspect of a management regimen aimed at reducing the systemic derangements and endotoxemia induced by EHBO. During EHBO, endotoxemia is partly caused by overgrowth of gram-negative bacteria in the intestinal lumen. Lactulose inhibits colonic bacterial growth by decreasing ammonia absorption from the gut, assists in altering the composition of the luminal microflora, and promotes movement of intestinal contents through the gut. This has the overall effect of decreasing intestinal permeability and thus improving intestinal barrier function.[31] Numerous studies in rats have documented beneficial effects of administration of oral lactulose on the intestinal lumen.[32,53,54] In a study of EHBO in a mouse model, pretreatment with oral lactulose before surgical intervention reduced mortality from 36% to zero.[54] Similarly, preoperative oral lactulose resulted in increased survival times in an experimental study on jaundiced rats.[33] The beneficial effects of oral lactulose in management of biliary obstruction were also seen in a prospective clinical study in humans, in whom significant reductions in both portal and systemic endotoxemia as well as protection of renal function were observed.[27]

Early enteral or intrajejunal feeding may also be a key component in reducing endotoxemia, with attendant decreases in systemic inflammation and injury to multiple organ systems. Enteral feeding improves intestinal permeability, reverses mucosal layer atrophy, and has been shown in dogs to lower serum endotoxin levels within 5 to 21 days.[34]

In what may be a similar effect, enteral supplementation with glutamine has been experimentally shown to have numerous positive effects on the intestinal mucosa of patients with EHBO.[55,56] Glutamine is a luminal amino acid that improves intestinal barrier function by promoting growth and function of normal intestinal epithelial structures. In one study that examined changes in intestinal permeability in rodents with bile duct ligation, animals receiving a 7-day regimen of enteral glutamine had significantly lower permeability to bacterial translocation and endotoxin compared with animals not receiving glutamine.[55] This same study also documented that subjects receiving glutamine had significantly reduced weight loss. A similar impact on endotoxemia was shown by another group receiving oral glutamine[56]; this effect was not mimicked by oral bile salt replacement alone.

Internal bile replacement during percutaneous external bile drainage also plays an important role in recovery of intestinal barrier function and normalization of intestinal microfloral populations.[13,35] A number of research groups have documented substantial improvements in the normal function and permeability of the small intestine in people receiving bile replacement during external biliary drain-

age.[13] Similar results have been obtained in experimental animal studies.[56] Together, these studies strongly support the use of oral lactulose, early enteral feeding, glutamine supplementation, and, when possible, internal bile replacement as practical steps with significant positive benefits in the management of EHBO.

As with all critical care patients, patients with EHBO must receive appropriate supportive care. Intravenous fluid therapy, imbalances in electrolytes, and acid–base abnormalities should be assessed and corrected as needed. Due to the prominent role of bacterial overgrowth, translocation, and colonization of sites distant to the gut in EHBO, broad-spectrum antimicrobial prophylaxis should be administered. Broad-spectrum treatment for aerobic and anaerobic organisms is warranted. Anaerobes can be effectively covered by either ampicillin (dogs and cats, 10 to 20 mg/kg PO bid for at least 10 to 14 days)[57] or metronidazole (dogs, 25 to 30 mg/kg PO bid for at least 10 to 14 days; cats, 7.5 mg/kg PO bid or tid for at least 10 to 14 days).[58] Clindamycin has anaerobic and gram-positive antibacterial efficacy (dogs and cats, 5 to 11 mg/kg PO bid for at least 10 to 14 days).[58] These drugs may be combined with a cephalosporin, such as cefazolin or cefoxitin, or a fluoroquinolone for broader aerobic antibacterial coverage. Antibiotic therapy should be adjusted based on culture and sensitivity results. Drug therapy to promote intestinal motility and suppress vomiting as well as other therapies for coagulopathies, pancreatitis, or other comorbidities should be instituted based on the best judgment of the attending clinician.

Conclusion

EHBO is a difficult clinical problem with a high mortality rate in animals. Emergent presurgical biliary drainage is a promising approach that has not been widely used in veterinary medicine and may be an integral component of EHBO patient management. Numerous improvements in systemic homeostatic mechanisms are seen quickly after external biliary drainage and have the potential to substantially lower surgical mortality. For some inflammation-mediated etiologies of EHBO, external biliary drainage may serve as definitive therapy. Laparoscopy-guided transperitoneal PC catheters are our method of choice for biliary drainage based on the high placement success rate, ability to visualize the gallbladder, minimal anesthetic time required for placement, and potential for use as a therapeutic intervention and an aid in serial assessment of the patency of the bile duct system.

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