PORTOSYSTEMIC SHUNTS

Karen M Tobias, DVM, MS, Diplomate ACVS
Professor, Small Animal Surgery
University of Tennessee, Knoxville TN

Pathophysiology of PSS

Portosystemic shunts (PSS) are abnormal connections between the portal system (splenic, phrenic, cranial mesenteric, caudal mesenteric, gastric, or gastroduodenal veins) to the caudal vena cava or azygos vein. Congenital intrahepatic PSS result from persistence of the ductus venosus or form during fetal development of hepatic sinusoids and portal vessels. They are usually found in large and medium sized breeds of dogs, such as Irish wolfhounds, Labrador retrievers, old English sheepdogs, and Australian shepherds. They have also been reported in some cats and in small breeds, particularly miniature poodles. Single congenital extrahepatic portosystemic shunts connect the portal vein or one of its tributaries to the caudal vena cava or the azygos vein. They are usually found in small breed dogs, such as pugs, schnauzers, Maltese, Shih tzus, and especially Yorkshire terriers, and are the most common type of congenital shunt in cats. They have also been reported in large breed dogs.

Extrahepatic multiple acquired portosystemic shunts connect the portal tributaries to the caudal vena cava, usually near the renal veins. They occur as a result of end stage liver disease (cirrhosis) and portal hypertension. These abnormal vessels are present microscopically in normal dogs and will enlarge when portal pressure becomes too high for the portal system to tolerate. They are not surgically correctable.

Congenital portal vein hypoplasia (PVH) with secondary microvascular dysplasia (MVD) has occasionally been called “microscopic intrahepatic shunts”. The condition MVD is actually a pathologic change and can have many underlying etiologies (e.g. noncirrhotic portal hypertension, congenital PSS, congenital portal vein hypoplasia). Most commonly, this condition results from congenital portal hypoplasia (PVH), in which microscopic portal vessels are underdeveloped or absent at birth. Unfortunately, PVH occurs in the same breeds that are commonly affected with congenital extrahepatic PSS (Maltese, Yorkies, Cairn terriers, etc.) and can cause clinical signs and blood work changes similar to PSS, though usually to a lesser extent. This condition is not surgically treatable.

Clinical Signs and Laboratory Abnormalities

Clinical signs of PSS result from abnormalities of the nervous system, urinary tract, and digestive system. General signs in dogs and cats include poor weight gain, stunted growth, and poor recovery from barbiturate anesthesia. Cats often hypersalivate. Neurologic abnormalities are most common, particularly behavioral changes, depression, disorientation, seizures, blindness, and ataxia. Seizures are seen in over 65% of cats. Some older dogs may only present with signs of cystitis or urinary tract obstruction (dysuria, pollakiuria, hematuria, stranguria) from urate calculi and ammonium biurate crystals. Gastrointestinal signs include vomiting and diarrhea. Ascites is very uncommon in animals with congenital PSS and is usually an indication of multiple acquired shunts. It may also occur with severe hypoalbuminemia.

Clinical signs of hepatic encephalopathy include dementia, stupor, seizures, tremors, and coma and are caused by increased sensitivity to toxins and drugs. Ammonia and other toxins are produced from protein breakdown in the colon. Hepatic encephalopathy can be precipitated by

high protein meals, intestinal hemorrhage (such as from parasites), transfusion with stored blood, infection, constipation, and drugs such as anesthetics, analgesics, and tranquilizers. Severe hepatic encephalopathy should be treated with intravenous fluids, warm water enemas, antibiotics (e.g., neomycin, amoxicillin, or metronidazole), and lactulose by mouth or per rectum.

Laboratory abnormalities include changes in the complete blood count (CBC), biochemistries, and urinalysis. On CBC, microcytic anemia may be present. Decreases in blood urea nitrogen and albumin are common in dogs, and glucose may be low. Liver enzymes may be increased, especially in cats. Urine specific gravity is often decreased, and ammonium biurate crystals may be seen in the urine sediment (400X magnification). Serum bile acid concentrations are increased because of poor liver function. Fasting bile acids are less than 5-15 µmol/L in normal dogs and are greater than 25 µmol/L in 95% of dogs with shunts. Bile acids measured 2 hours after a meal are usually greater than 75 µmol/L in dogs with PSS; however, one study found that over 10% of dogs with PSS had fasting and fed bile acids of 25 µmol/L or less. Some normal Maltese may have falsely elevated bile acids because of a chemical that interferes with spectrophotometry. Ammonia tolerance tests can also be used to diagnose liver dysfunction, since NH_3 is increased in 90% to 100% of dogs with PSS.

Liver biopsy results include atrophy, decreased numbers of portal tributaries, and proliferation of arterioles and bile ductules. These results may also be present in dogs with PVH/MVD.

Diagnosis of Portosystemic Shunts

Increased bile acids or ammonia or presence of ammonium urate crystals in a puppy with clinical signs of hepatic encephalopathy is suggestive of portosystemic shunting. On plain abdominal radiographs, a small liver may be seen. Animals with shunts may also have large kidneys or calculi in the bladder or kidneys (urate stones are usually radiolucent but will be radio-opaque if they also contain struvite). Shunts may be detected during ultrasound examination of the abdomen; intrahepatic shunts are easier to find with ultrasound because they are very large. Even if the shunt is not visualized on ultrasound, other clues may be found, including sediment in the kidneys and bladder, increased kidney size, decreased portal vein size (if there is a congenital extrahepatic shunt), and turbulent blood flow. Another method for detecting shunting is to inject agitated saline into the spleen and to simultaneously ultrasound the right atrium or distal caudal vena cava for air bubbles.

Portograms provide diagnosis and location of shunts in all animals. Radio-opaque, sterile, water soluble contrast is injected into a catheterized jejunal or splenic vein (maximum total dose, 2 ml/kg). Radiographs (left lateral is best) are taken 1-3 seconds after beginning the injection, or continuously if a fluoroscope is available. A direct injection of the spleen can also be performed; however, less contrast reaches the shunt quickly and contrast that remains in the spleen may obscure the shunt itself.

Diagnosis can also be made with nuclear scintigraphy. Trans-splenic scintigraphy (injection directly into the spleen) provides a portogram in some animals, and in about 70% of animals allows differentiation between multiple extrahepatic and single congenital PSS. An overnight stay is required because animals are radioactive after the procedure. The gold standard for shunt diagnosis is dual phase computed tomographic angiography, which allows reconstruction of the vessels and identification of vessel number, location, and termination.

Differential Diagnoses

Any liver disease can cause bile acids and ammonia to increase. Dalmatians and other breeds can have urease deficiencies that result in production of ammonium biurate crystals. Hepatic encephalopathy must be differentiated from distemper, hydrocephalus, hypoglycemia, toxicities, and epilepsy. PVH/MVD causes the same clinical signs and laboratory and biopsy changes as extrahepatic congenital portosystemic shunts; however, results of advanced imaging techniques are normal. Dogs with acquired multiple extrahepatic shunts may have ascites and coagulation abnormalities. In these dogs, coagulation should be checked before taking a liver biopsy.

Characteristics	Portal Vein Hypoplasia	EH CPSS
Signalment	Small/toy breed dogs	Small/toy breed dogs
History	Usually asymptomatic	Usually symptomatic
Response to treatment	Usually none	Often good
Albumin, glucose, BUN, MCV (red cell size), urine specific gravity	Usually normal	Usually abnormal
Liver enzymes	Normal to increased	Normal to increased
NH4 biurate crystals	Usually absent	Often present
Fasting bile acids	Usually normal	Usually abnormal
Fed bile acids	Usually <70 μmol/L	Usually >70 μmol/L
Protein C activity	Usually >70%	Usually <60%
Liver biopsy	MVD	MVD
Ultrasound	Normal or small liver	May see: Small liver, big kidneys, shunt, evidence of crystals in urinary tract
Scintigraphy	Normal	Shunting
CT, MRA, Portogram	Normal	Shunting
Hereditary	Yes	Yes

Medical Management of Portosystemic Shunts

Dogs with neurologic signs should be placed on intravenous fluids with dextrose and given an enema with warm water and lactulose. Seizures are initially treated with diazepam or another benzodiazepine, and the animals are placed on levetiracetam. A protein-restricted, highly digestible liver diet is essential for all animals with PSS. Dogs with shunts need at 2 gm protein/kg body weight (higher than the protein content in many kidney diets). Hill's L/D and Royal Canine Hepatic are excellent prescription diets; if additional protein is desired, the owners can add a couple of teaspoons of yogurt with active cultures. Lactulose syrup decreases ammonia production and absorption by acidifying the colon and acting as a cathartic. Oral antibiotics (neomycin or metronidazole) help to control clinical signs if diet and lactulose are not enough. Intestinal parasites and gastrointestinal bleeding are treated to reduce protein in the intestines and improve the animal's health. Nutriceuticals (denosyl [SAM-e] and milk thistle [Marin, Denemarin]) may improve hepatic regeneration and detoxification; veterinary formulations are recommended since many of the over-the-counter brands do not actually contain a sufficient amount of active ingredients. Large breed dogs and any small breed dog with suspected gastrointestinal bleeding should be placed on omeprazole.

Prognosis with long-term medical management is good in dogs with good portal blood flow (about 35% of dogs) and poor in the rest. The average survival time for medically managed dogs is about 2 years. There are no good predictors of which animals will do well with medical treatment alone, although dogs that are older at presentation, have minimal clinical signs, and have BUN and albumin concentrations close to normal will probably do better. Affected animals should not be bred, since PSS are proven to be inherited in Irish wolfhounds, Maltese, Yorkies, and many other breeds.

Surgical Management of Portosystemic Shunts

Surgery is the treatment of choice for single congenital shunts to encourage return of hepatic blood supply and regeneration of hepatic tissue and to discourage progressive liver atrophy and fibrosis. Most veterinarians refer these patients to an experienced surgeon.

Acute complete occlusion of shunts can cause death from portal hypertension. Ameroid constrictors or cellophane bands can be placed on extrahepatic shunts (at their insertion site on the caudal vena cava or azygous vein) and many intrahepatic shunts. An ameroid constrictor consists of a stainless steel ring with an inner casein core. The casein absorbs abdominal fluid and swells (therefore the ring must be gas sterilized) and then causes a fibrous tissue reaction. The constrictor causes the shunt to stricture closed gradually over 2-4 weeks. Some dogs may still develop postoperative portal hypertension if the ring is too small (causing greater than 25% constriction of the shunt) or is too loose (flipping and causing acute obstruction of the shunt). Like ameroid constrictors, cellophane bands cause fibrosis that closes the shunt. Like ameroid constrictors, cellophane band diameter should be larger than shunt diameter to avoid portal hypertension. If suture ligation is used, the degree of vessel constriction is based on portal pressure; in most dogs the shunt is only partially ligated.

Options for treatment of intrahepatic shunts include surgical ligation of the hepatic vein draining the shunt or the portal branch supplying the shunt, intravascular occlusion of the shunt, or ligation of the shunt itself, or placement of embolization coils. Severe hemorrhage and hepatic congestion are potential complications during intrahepatic shunt ligation.

Postoperative Care of Portosystemic Shunt Patients

Animals must be kept quiet and pain-free for several days after surgery. Acepromazine does not increase risk of seizures after shunt surgery and is very useful for sedating these patients. Another alternative is a continuous rate infusion of low dose dexmedetomidine. Many toy breed dogs will develop hypoglycemia immediately after surgery, even on dextrose. If glucose decreases below 60 mg/dL or the dog does not recover well from anesthesia, dexamethasone (0.02-0.05 mg/kg IV) is administered. Glucose will stabilize once the dogs eat.

Seizures occur up to 96 hours after surgery in 2-18% of animals; in fact, some owners report seizures as late as 7-9 days after surgery. The cause is unknown. Seizures can be initially stopped with diazepam. The animals are checked for increased ammonia or decreased glucose; if these are normal, they are started on levetiracetam. If seizures reoccur and are not caused by hyperammonemia (hepatic encephalopathy) or hypoglycemia, the animals should be heavily sedated with a continuous infusion of propofol for 12 – 24 hours. Mannitol treatments are given once or twice daily to reduce cerebral edema, and IV phenobarbital is started while the animal is on the propofol infusion. Nursing care may be required for days while the animal is weaned off the propofol. We treat dogs with acepromazine or dexmedetomidine; many times this prevents seizures or stops them from reoccurring.

Animals that undergo PSS ligation require supportive therapy and close monitoring for signs of portal hypertension (hypovolemic shock, progressive hypothermia, severe abdominal pain); if these signs occur, the animal should be taken back to surgery for ligature removal. A second partial ligation can be performed after the animal has recovered completely from the surgeries and portal hypertension. Mild portal hypertension may be seen in some animals 2-4 weeks after surgery and is usually evidenced by abdominal distension from fluid accumulation. No treatment is required unless the animal is having trouble breathing; in that case, the animal is treated with diuretics (e.g. furosemide) and, if albumin is low, hetastarch.

Lactulose is continued for a minimum of 2-4 weeks, based on clinical signs and severity of the disease. Yogurt with active cultures or probiotics (live bacterial cultures) may be as beneficial as lactulose in some dogs. Protein restricted diets are fed until the animal shows signs of improved hepatic function (i.e. normal albumin or normal scintigraphy). Serum bile acids often continue to be abnormal after shunt ligation; in one study, 75% of dogs had abnormal values a median time of 18.6 months after ligation. If bile acids are abnormal at 3 months, protein restricted diet is continued and the animal is started Marin or Denamarin (milk thistle or silymarin). If blood work is still abnormal 6 months after the surgery, the dog should be rechecked for shunting (portogram, scintigraphy, ultrasound) and undergo a liver biopsy to determine if the problem is caused by incomplete closure of the original constricting device, presence of a second congenital shunt or multiple acquired shunts, or hepatic microvascular dysplasia or another liver disease.

Prognosis for PSS Patients

Prognosis for dogs is excellent after ameroid constrictor placement or cellophane banding, with 85% of dogs becoming clinically normal within 4 months of surgery. Intrahepatic shunts may have a higher surgical mortality rate (5-25%) due to the difficulty of the surgery. Mortality rates are lower with coil embolization of intrahepatic shunts, as long as the dogs are kept on gastroprotectants (e.g., omeprazole) for life. Recurrence of clinical signs is seen in up to 50% of dogs with partial (suture) shunt ligation about 3 years after surgery; many of these dogs developed multiple PSS.

Cats may have recurrence of clinical signs and revascularization of the shunt if the original shunt is only partially occluded. Long-term prognosis is poor in 25% of cats and is much worse in cats with uncontrollable seizures. Many cats have recurrence of clinical signs within a year and many die or are euthanized after surgery.