The spleen

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Surgical conditions of the spleen are commonly encountered in small animal practice. In some instances splenic biopsy or partial splenectomy may be warranted, but in most cases splenectomy is the treatment of choice. The spleen is a part of the reticuloendothelial system and, although it has several important functions, it is not essential for life. Overwhelming septicæmia, occasionally observed in humans after splenectomy, has not been reported following splenectomy in dogs or cats.

Anatomy

The spleen is suspended by the greater omentum and is attached to the greater curvature of the stomach by the gastrosplenic ligament (Figure 12.1). The spleen is usually located in the left cranial quadrant of the abdomen in the dog and cat, although the position can vary owing to the mobile nature of the abdominal organs. It can be located under the rib cage if the stomach is empty but in the presence of gastric distension it may move to a more caudal position within the abdomen.

The spleen is normally firm and red, but it may have white fibrin deposits or yellowish-brown siderotic plaques (iron and calcium deposits) on its surface (Figure 12.2). The blood supply is via the splenic artery, which arises from the coeliac artery and supplies branches to the left lobe of the pancreas as it courses to the splenic hilus (Figure 12.3). As the splenic artery terminates at the spleen, it divides into a dorsal and ventral branch. The dorsal branch

continues to the dorsal portion of the spleen and gives off the short gastric arteries. The ventral branch gives off the left gastroepiploic artery before it contacts the spleen. Venous drainage from the spleen is via the gastrosplenic vein, which empties into the portal vein.

12.2 Siderotic plaques on the tail of the spleen.

12.1 Gastrosplenic ligament containing the short gastric arteries and veins.

12.3 The blood supply to the spleen.

The spleen is composed of a capsule (elastic and smooth muscle fibres), internal trabeculae (collagen, elastin and smooth muscle fibres) and parenchyma (white and red pulp). Unlike in the human spleen, the abundance of smooth muscle cells in the spleen of cats and dogs enables it to contract and relax under the control of alpha-adrenergic receptors.

Function

The two components of the splenic parenchyma have separate functions. The white pulp is lymphoid tissue, and is a major site of trapping and immunological recognition of blood-borne antigens and antibody production. The red pulp is composed of venous sinuses and cellular tissue (consisting of red and white blood cells, megakaryocytes and macrophages) filling the intravascular spaces. It serves as a reservoir of erythrocytes and platelets and is also a highly efficient filter that clears circulating blood of particulate matter, such as bacteria and aged or damaged blood cells. The functions of the spleen include the following:

- Blood filtration
- Phagocytosis of aged or damaged red blood cells, parasites, bacteria and other particles
- Extramedullary haemopoiesis. This function normally ceases after birth and the bone marrow takes over the role; however, if bone marrow haemopoiesis is disrupted (e.g. myeloproliferative diseases, immune-mediated haemolysis, immune-mediated thrombocytopenia, chronic inflammatory or infectious diseases) the spleen can resume a limited degree of haemopoietic activity
- Erythrocyte and platelet storage. Dog and cat spleens have large sinusoidal spaces that can store between 10% and 20% of the circulating red blood cell mass and 30% of the total platelet mass. Splenic contraction mobilizes the stored blood under conditions of stress, hypoxaemia or blood loss to maintain appropriate circulating volume and oxygen-carrying capacity
- Immune functions. The spleen produces the majority of B and T lymphocytes in adult animals and the germinal centres of the spleen are the major sites of immunoglobulin M production
- Miscellaneous functions, including iron metabolism, regulation of angiotensin-converting enzyme levels, storage and activation of factor VIII.

Surgical techniques

Surgical biopsy

See Operative Technique 12.1. Indications for splenic biopsy include:

- Evaluation of nodular or focal masses
- Evaluation of clinically significant diffuse splenomegaly or abnormal ultrasonographic echogenicity
- Confirmation of any suspected metastatic lesions of the spleen.

Via a ventral midline laparotomy, biopsy samples from focal lesions may be taken with a core biopsy needle or using a skin biopsy punch (see Chapter 9).

Partial splenectomy

Partial splenectomy is indicated in animals with traumatic or focal lesions of the spleen, such as an isolated abscess. Although performed rarely, a partial splenectomy (see Operative Technique 12.1) allows preservation of splenic function. It is not recommended for splenic neoplasia even though the tumour mass may grossly involve only one portion of the spleen. Several techniques have been reported, differing in the method by which the parenchyma is transected and handled.

Splenectomy

Complete splenectomy is the most commonly performed splenic surgery (see Operative Technique 12.2). The two most commonly performed techniques involve either individual ligation of the hilar vessels or ligation of the major splenic arteries and veins as well as the short gastric arteries. Individual ligation of the hilar vessels is time-consuming and studies have shown that gastric blood flow is not compromised by ligation of the short gastric arteries and veins, or the left gastroepiploic artery and vein.

Absorbable monofilament suture material is most widely used for vessel ligation when performing splenectomy but there are a variety of other techniques available, including the use of metal haemostatic clips, mono- and bipolar electrocautery and ultrasonic-activated scalpels (see Chapter 9). Haemostatic clips can be placed rapidly but can be unstable and may be removed or dislodged easily. They should only be used on vessels less than 3–4 mm in diameter. Ultrasonic scalpels can seal vessels up to 5 mm in diameter; thus, ligatures are required for adequate haemostasis of the splenic artery and vein in large dogs. Recently, the use of a bipolar vessel sealant device was described for splenectomy in dogs (Rivier and Monnet, 2011). These devices involve an electrothermal bipolar sealing system, which achieves haemostasis by compression of vessels in the jaws of the instrument and heat-induced fusion of collagen and elastin in the vessel walls. In human patients, vessels up to 7 mm in diameter can be safely coagulated. In the report by Rivier and Monnet (2011), the splenic artery was sealed three times with an overlap of the seals, and the vein was sealed twice. None of the dogs required any vessel ligation with suture material but one dog developed a haemoabdomen postoperatively. Until more studies are performed, the routine use of bipolar vessel-sealing devices cannot currently be recommended for ligation of the main splenic artery and vein.

Indications for total splenectomy include:

- Splenic neoplasia
- Splenic rupture secondary to trauma
- Splenic torsion.

In the USA, elective splenectomy may be performed in dogs used as blood donors to prevent the spread of infections involving *Haemobartonella canis* or *Babesia canis*.

The major disadvantages of splenectomy are the loss of the reservoir, immune defence, haemopoiesis and filtration functions. Splenectomy is contraindicated in patients with immune-mediated haemolytic anaemia or thrombocytopenia unless other forms of treatment (e.g. immunosuppressive drugs) have failed. It is also contraindicated for patients with bone marrow hypoplasia; in these patients the spleen is the main site of haemopoiesis.

Laparoscopy

Splenic biopsy and partial and complete splenectomy using laparoscopic equipment has been described in both the dog and the cat (Khalaj *et al.*, 2012; Radhakrishnan and Mayhew, 2013). These techniques are not applicable in cases where emergency treatment of a haemoabdomen associated with a ruptured splenic mass is required.

Splenic conditions

In the majority of cases, splenic disease results in either diffuse or focal splenic enlargement (Figure 12.4). It is worth noting that dogs more frequently have focal splenic enlargement while cats more frequently have diffuse splenic enlargement. A wide range of conditions can cause diffuse splenomegaly (Figure 12.5). Causes of focal splenic enlargement are listed in Figure 12.6. In one study, the pathological findings in 87 dogs with splenic abnormalities revealed that the most common diagnosis was splenic neoplasia ($n = 38$) and the most frequently recognized canine splenic neoplasm was haemangiosarcoma (HSA; 17 of 38 cases). Benign splenic enlargement secondary to nodular hyperplasia, haematoma or non-specific changes, including congestion, haemorrhage, extramedullary haemopoiesis and haemosiderin deposition, was also recognized (Day *et al.*, 1995).

Clinical signs and diagnosis

Clinical signs are variable and often non-specific in animals with splenic disease. Subtle signs, such as abdominal distension, anorexia, lethargy, polydipsia, vomiting or

Infiltrative ^a	<ul style="list-style-type: none"> Neoplastic – leukaemia, lymphoma, systemic mastocytosis, multiple myeloma, malignant histiocytosis (dogs) Non-neoplastic – extramedullary haemopoiesis, hypereosinophilic syndrome (cats)
Infectious	<ul style="list-style-type: none"> Bacterial – septicæmia Viral – feline infectious peritonitis (caused by feline coronavirus; cats), infectious canine hepatitis (dogs) Parasitic – <i>Haemobartonella</i> Fungal – histoplasmosis and blastomycosis (USA)
Hyperplastic	<ul style="list-style-type: none"> Immune-mediated – haemolytic anaemia or thrombocytopenia Hypersplenism – can be primary but splenomegaly is usually secondary to an underlying disease process that causes any combination of anaemia, leucopenia and thrombocytopenia, with secondary bone marrow hyperplasia and resolution of cytopenia following splenectomy
Congestive	<ul style="list-style-type: none"> Splenic torsion – alone or in conjunction with gastric dilatation and volvulus (GDV) Portal hypertension – secondary to right-sided heart failure or caudal vena cava obstruction Drug-induced – barbiturates or tranquilizers

12.5 Causes of diffuse splenic enlargement. ^a Most common causes of splenomegaly.

Neoplastic (primary or metastatic)

- Haemangiosarcoma
- Haemangioma
- Sarcoma

Non-neoplastic

- Nodular hyperplasia (can be single or multiple benign accumulations of lymphoid cells and is the most commonly encountered splenic mass in dogs)
- Haematoma (may be the result of trauma)
- Abscess (rare)
- Fibrohistiocytic nodules (hyperplastic lymphoid proliferation containing distinct population of spindle cells)

12.6 Causes of focal splenic enlargement.

12.4 (a) Diffuse splenomegaly due to an undifferentiated sarcoma. (b) Focal splenomegaly due to a splenic haemangiosarcoma.

depression, may be noted, or the patient may present with acute signs of weakness or collapse associated with haemorrhage from a ruptured HSA. In these cases the history may also reveal intermittent episodes of weakness or collapse, often with spontaneous recovery within 12–24 hours. These episodes are associated with haemorrhage and subsequent blood reabsorption.

Physical examination findings in animals with splenic disease include:

- Abdominal distension (due to either splenic enlargement or haemorrhage)
- Pain on abdominal palpation
- Pale mucous membranes
- Petechiae or ecchymoses
- Enlarged peripheral lymph nodes
- Fever.

The normal spleen can be palpated in many animals and splenomegaly may often be detected on abdominal palpation. Additional diagnostic imaging modalities are frequently required for definitive diagnosis of splenic enlargement. Care should be taken when assessing splenic size in the anaesthetized patient because the use of barbiturates and propofol may lead to significant splenomegaly.

Radiography and ultrasonography

Abdominal radiographs often reveal an abdominal mass; however, ultrasonography is regarded as more useful in all cases and particularly when there is a significant haemo-abdomen. Ultrasonography is especially useful for localizing a mass to the spleen, performing needle aspiration and evaluating the rest of the abdomen for the presence of metastasis (Figure 12.7). Additionally, the parenchyma of the spleen and vasculature can be assessed, which may aid in the diagnosis of splenic torsion. Advanced imaging techniques, such as computed tomography (CT) (Figure 12.8) or magnetic resonance imaging (MRI), readily demonstrate splenic enlargement but their use is rarely necessary or practical.

12.7 Ultrasonographic appearance of a splenic haemangiosarcoma.

12.8 CT scan showing a large splenic mass localized to one end of the spleen (arrowed).

PRACTICAL TIP

In any case of splenomegaly, three-view thoracic radiographs should be taken to evaluate for metastatic disease. In addition, echocardiography can be performed to evaluate for right atrial masses in cases of suspected splenic HSA

Biopsy

Splenic biopsy is indicated to ascertain the cause of clinically significant splenomegaly or to evaluate suspected metastatic lesions. Biopsy may be performed percutaneously by fine-needle aspiration, or at surgery. Use of ultrasound guidance improves the likelihood of obtaining diagnostic samples percutaneously because it allows focal lesions to be targeted; it is also of diagnostic value for diffuse lesions, but it should be noted that some focal lesions may be missed. The technique for fine-needle aspiration is as follows:

1. Place the animal in right lateral or dorsal recumbency, using manual restraint or mild sedation. Avoid using phenothiazine tranquilizers or barbiturates, because the resultant splenic congestion may cause a non-diagnostic sample due to blood dilution.
2. Surgically prepare a small area on the side of the abdomen and isolate the spleen.
3. Using a syringe attached to a 23–25 G needle (2.5–3.5 cm; 1–1.5 inches), penetrate the abdominal wall and advance the needle into the spleen. Apply suction several times.
4. Before removing the needle from the abdomen, relieve suction on the syringe to prevent aspiration of the contents of the needle into the syringe.

WARNING

Splenic aspiration is contraindicated in animals with cavitary lesions. The lesions may rupture during the procedure and this may be fatal, especially in animals with coagulopathies

Splenic torsion

Splenic torsion, or rotation of the spleen about its vascular pedicle, is an uncommon condition most frequently reported in large- or giant-breed dogs. German Shepherd Dogs and Great Danes appear to be predisposed (Neath *et al.*, 1997). It is frequently associated with gastric dilatation and volvulus (GDV; see Chapter 6) but can also occur in the absence of GDV. Primary splenic torsion occurs in both acute and chronic forms and can be difficult to diagnose, owing to the non-specific and sometimes chronic or intermittent clinical signs.

Acute splenic torsion usually causes severe abdominal pain and cardiovascular collapse over a few hours.

- Signs include weakness, salivation, retching and collapse.
- Dogs may present with pale mucous membranes, poor capillary refill, tachycardia and abdominal splinting.
- An enlarged spleen may be palpable.
- Bloodwork is often unremarkable.

In *chronic splenic torsion* the signs are vague:

- Dogs present with lethargy, depression and anorexia. They may also vomit intermittently or have diarrhoea
- Acute deterioration can occur
- Reported bloodwork abnormalities include anaemia, leucocytosis, haemoglobinaemia, and elevated serum alkaline phosphatase (ALP) and alanine aminotransferase (ALT) levels. Pancreatic enzyme concentrations (amylase and lipase) may also be elevated.

Radiographs often show a cranial to mid-abdominal mass, absence of the normal splenic silhouette, or a C-shaped spleen (Figure 12.9a). In cases of chronic splenic torsion, infarction and ischaemia can lead to gas densities in the region of the spleen. Abdominal detail may be poor as a result of peritoneal effusion. Ultrasonography may reveal diffuse splenomegaly and a hypoechoic pattern in the splenic parenchyma. Colour-flow Doppler ultrasonography is most reliable for diagnosis. In a study by Neath *et al.* (1997), decreased blood flow in the splenic veins was demonstrated in 92% of cases, and intravascular thrombi in 50% of cases. In cases where abdominal radiography and ultrasonography are not conclusive, contrast-enhanced CT has been used to demonstrate torsion of the splenic pedicle (Patsikas *et al.*, 2001). A corkscrew-like soft tissue mass representing the splenic pedicle, in conjunction with lack of contrast enhancement of the splenic parenchyma, is considered pathognomonic for the condition.

Treatment of acute or chronic splenic torsion is by splenectomy (Figure 12.9b). Animals that present with acute collapse and hypotension should be stabilized prior to surgery, and careful monitoring for cardiac arrhythmias should be carried out in the pre-, peri- and immediate postoperative period.

12.9

Splenic torsion. (a) Ventrodorsal abdominal radiograph of a dog with splenic torsion. Note the C-shaped spleen (arrowed).

(b) Splenic pedicle; note the 'corkscrew' appearance.
(b, Courtesy of S Birchard)

WARNING

The splenic pedicle should not be untwisted prior to splenectomy. This can cause the release of thrombi, free radicals, toxins and vasoactive compounds such as tumour necrosis factor from the ischaemic spleen into the portal circulation

The splenic pedicle should be gradually divided and ligated to achieve adequate haemostasis. Mass ligation should be avoided.

PRACTICAL TIP

Although the relationship between splenic torsion and GDV is not clear, it has been suggested that repeated episodes of gastric dilatation may stretch the gastrosplenic ligament sufficiently to allow splenic hypermotility. Since deep-chested breeds of dog present with splenic torsion, prophylactic gastropexy should be considered at the time of splenectomy

The prognosis for acute splenic torsion is variable and dogs may develop splenic necrosis, sepsis, pancreatitis, peritonitis and/or disseminated intravascular coagulation (DIC). Chronic splenic torsion usually carries a good prognosis because these cases tend to have a lower incidence of cardiovascular shock and toxemia than cases of acute splenic torsion.

Splenic infarction

Splenic infarction can occur in association with splenic torsion, but infarction without torsion is a rarely described condition. In one retrospective study (Hardie *et al.*, 1995), 16 dogs with splenic infarction were identified. These dogs often had multiple concurrent diseases, including cardiac, renal or liver disease, neoplasia, or evidence of sepsis, coagulopathy or vasculitis. Clinical findings included anorexia, intermittent vomiting, lethargy, diarrhoea, pale mucous membranes, abdominal mass, effusion or pain, cardiac arrhythmias, polyuria, polydipsia and fever. However, it was difficult to determine which findings were due to splenic infarction and which were due to the concurrent disease.

Ultrasound examination findings include thrombosis within a splenic vein, loss of blood flow to a section of spleen, a diffuse 'lacy' appearance throughout the spleen, or an enlarged hypoechoic ventral extremity.

At surgery infarctions can be nodular or wedge-shaped with the base at the periphery (Figure 12.10) and can involve an extremity or the entire organ. Given that

12.10

Wedge-shaped splenic infarct.

splenic infarction is regarded as an indicator of altered blood flow and coagulation abnormalities, rather than as a primary disease, surgery carries a high mortality rate in these patients. Medical management is often preferable to splenectomy. Surgery should be reserved for animals with life-threatening complications such as haemoperitoneum or sepsis.

Splenic trauma

Traumatic injury to the spleen is uncommonly reported. Mild trauma can result in the formation of a subcapsular haematoma. Major trauma may result in deep parenchymal lacerations or crush injury associated with life-threatening haemorrhage. If the animal fails to respond to conservative therapy, partial or complete splenectomy may be indicated. In humans, preservation of splenic function is of primary importance. Splenic lacerations can be repaired with absorbable sutures or by 'splenic wrapping', which involves wrapping the spleen in a mesh bag made from absorbable suture material.

Splenic trauma can lead to dissemination of splenic tissue throughout the abdominal cavity and the subsequent development of 'splenosis', in which pieces of splenic tissue remain viable, suspended within the omentum. This is often found incidentally during abdominal exploratory surgery.

Splenic neoplasia

Splenic neoplasia is the most common reason for performing a total splenectomy in general practice. Tumours of the spleen may arise from a variety of tissues, including blood vessels, lymphoid tissue, smooth muscle and connective tissue. Non-neoplastic lesions include hyperplastic lymphoid nodules (which can be single or multiple, and are an uncommon problem in cats), haemangiomas, hamartomas and haematomas. The most common malignant splenic tumour in dogs is HSA, accounting for up to 80% of splenic malignancies identified (Weinstein *et al.*, 1989). Other malignant neoplasms include lymphosarcoma, mast cell tumour, leiomyosarcoma, fibrosarcoma, liposarcoma, osteosarcoma, chondrosarcoma, myxosarcoma, rhabdomyosarcoma and fibrous histiocytoma. In a recent study of 249 dogs with splenic masses, 117 dogs (47%) had non-malignant masses (nodular hyperplasia, haematoma, splenitis) and 132 dogs (53%) had malignant tumours, among which HSA was the most common (Eberle *et al.*, 2012). Splenic tumours reported in cats include lymphosarcoma and mast cell tumours, but HSAs are rare.

Haemangiosarcoma

HSA is a highly malignant tumour derived from vascular endothelial cells and is characterized by early and aggressive metastasis. It is usually seen in older large-breed dogs, but there are sporadic reports of HSAs occurring in younger animals. German Shepherd Dogs are predisposed. Other commonly reported breeds include Golden Retriever, Pointer, Boxer, Labrador Retriever, English Setter, Great Dane, Poodle and Siberian Husky (Brown *et al.*, 1985).

HSAs can arise in any tissue with blood vessels, but the most common sites in dogs are the spleen (50–60%), right atrium (3–25%), subcutaneous tissues (13–17%) and liver (5–6%) (Brown, 1985).

WARNING

HSAs tend to metastasize rapidly via haematogenous routes to the liver, omentum (Figure 12.11), mesentery and lungs; overt metastasis is present in >80% of canine patients at clinical presentation (MacEwen, 2001)

12.11

Metastasis of haemangiosarcoma to the omentum.

In dogs, HSA is considered the sarcoma most likely to metastasize to the brain. Splenic and atrial masses coexist in up to 25% of dogs with HSA (Walters *et al.*, 1988), although whether one site is primary or whether multicentric HSA has developed is usually undetermined.

HSAs can be single or multiple in any organ and vary in size. They may contain areas of haemorrhage or necrosis, are poorly circumscribed and non-encapsulated and often adhere to adjacent organs.

WARNING

Splenic haematoma and haemangioma must be differentiated from HSA. Haematomas are also seen in older large-breed dogs and have a clinical appearance that resembles HSA. It is not possible to differentiate between these lesions by direct visualization

Histopathological examination of tissues is required to diagnose HSA or any other tumour type definitively. An excisional biopsy is preferred because it is both a diagnostic and a therapeutic procedure.

Clinical signs: Clinical signs most commonly reported in association with HSA include:

- Weakness
- Distension of the abdomen
- Increased pulse and respiratory rate
- Pale mucous membranes
- Tachypnoea
- Weight loss
- Sudden death.

Dogs with concurrent right atrial HSA may develop pericardial effusion and present with muffled heart sounds, arrhythmias and signs of right-sided heart failure.

The majority of all naturally occurring deaths from HSA are associated with haemorrhage due to tumour rupture, or DIC. Haematological abnormalities in dogs with splenic HSA are listed in Figure 12.12.

PRACTICAL TIP

All animals with suspected HSA should have radiographs taken of both the thoracic cavity and the abdomen

Abnormality	Percentage
Anaemia	68%
Thrombocytopenia	51%
Increased reticulocyte count	22%
Neutrophilia	67%
Increase in band neutrophils	70%

12.12 Haematological abnormalities in dogs with splenic haemangiosarcoma.

Treatment: Splenectomy is the treatment of choice for an animal with a suspected splenic HSA (see Operative Technique 12.2). The surgery should be as radical as possible to remove all locally affected tissue. Additionally, a biopsy should be performed on any suspicious lesions in the liver or omentum. Animals that present in acute hypovolaemic shock should be stabilized initially. Management of patients with haemoperitoneum is discussed below.

Prognosis: The prognosis for dogs with splenic HSA following surgery alone is very poor, with median survival times of 19–86 days (MacEwen, 2001). Death is usually due to metastatic disease. With the addition of chemotherapy following splenectomy, survival times of 141–179 days have been reported (MacEwen, 2001). Despite aggressive surgery and/or chemotherapy, survival times are short for almost all forms of primary HSA, with <10% of dogs surviving a year or longer.

Haemoperitoneum

Numerous diseases can result in a haemoperitoneum (Figure 12.13). The most common differential diagnoses include a bleeding neoplasm (HSA, hepatoma), coagulopathy (rodenticides) and trauma. Specific treatments are indicated for each final diagnosis. In general, neoplasia, GDV, splenic torsion and liver lobe torsion are treated surgically. Coagulopathy disorders are considered non-surgical. Trauma is usually managed conservatively. If the patient fails to stabilize, abdominal exploratory surgery may be warranted.

Traumatic

- Damage to the liver, spleen or kidneys can occur from blunt or penetrating trauma
- Breakdown in surgical haemostasis
- Haemorrhage from a biopsy site

Non-traumatic

- Neoplasia – splenic (HSA/haematoma), hepatic, renal, adrenal gland
- Other diseases – GDV, splenic torsion, liver lobe torsion
- Coagulopathies – congenital, acquired

12.13 Causes of haemoperitoneum.

Initially, the patient presenting with haemoperitoneum may be difficult to differentiate from other causes of acute abdomen (see Chapter 18). However, these patients usually present with pale mucous membranes, prolonged capillary refill time, severe lethargy or collapse, distended abdomen, fluid wave on ballottement, weak peripheral pulses, tachycardia and tachypnoea. A thorough history should be obtained immediately upon patient presentation. It may reveal recent trauma or surgery, documented splenic masses, episodes of collapse, coagulopathy or rodenticide consumption (Spangler and Kass, 1997). Patient signalment is inconsistent, but breed and age predilections exist for some neoplastic and congenital coagulopathy disorders.

Diagnosis

Confirming a suspected haemoperitoneum when a large amount of free abdominal fluid is evident on physical examination simply requires abdominocentesis.

PRACTICAL TIP

Serosanguineous abdominal fluid that does not clot readily and has a packed cell volume (PCV) >10% is considered diagnostic for haemoperitoneum

Diagnosis of the underlying cause is often more complicated. Cytological evaluation of the fluid will reveal numerous red blood cells, though occasionally neoplastic cells may be identified. It is important to remember that false negatives can occur with this technique. The abdomen has a tremendous capacity for absorbing and storing fluid. Failure to obtain blood on aspiration does not rule out haemoperitoneum. Diagnostic peritoneal lavage (DPL) is typically performed if abdominocentesis results are negative (see Chapter 18).

Haematology

A complete blood count may reveal changes in PCV. It is important to note that such changes can be variable, depending on the hydration status of the patient, underlying disease processes and time since onset of haemorrhage. For instance, dehydration may cause both PCV and total protein to increase owing to haemoconcentration. Patients with dehydration and haemorrhage may have a normal PCV. Persistent underlying diseases may contribute to an anaemia of chronic inflammatory disease, making a single PCV result difficult to interpret. Additionally, splenic contraction (a normal canine response to increased circulating catecholamines) may release enough red blood cells systemically to maintain a normal PCV for a short time in the face of acute haemorrhage. Perhaps more beneficial in the diagnosis of ongoing bleeding related to haemoperitoneum is serial monitoring of PCV and total protein. A recent study showed that dogs with splenic HSAs had significantly lower total protein and platelet counts than dogs with other splenic masses (Hammond and Pesillo-Crosby, 2008).

PRACTICAL TIP

A 5–10% decline in PCV in a 15-minute time period indicates severe ongoing haemorrhage

Less precipitous reductions of PCV can also suggest active bleeding. Moreover, serial PCVs, taken 10–30 minutes apart, may allow the clinician to decide whether medical or surgical intervention is most appropriate. Lastly, a serum chemistry panel and urinalysis need to be performed to evaluate the patient for any underlying disease processes.

PRACTICAL TIP

A coagulation panel should be performed for all patients with haemoperitoneum

Cardiac abnormalities

Cardiac auscultation may reveal a heart murmur. Left-sided physiological heart murmurs are commonly heard in patients with anaemia. An electrocardiogram (ECG) monitor may reveal cardiac arrhythmias. Ventricular premature contractions are commonly observed in patients with several disease processes, including haemoperitoneum, HSA, GDV, pancreatitis, trauma and mesenteric volvulus.

Diagnostic imaging

Frequently, abdominal masses can be diagnosed on plain abdominal radiographs, although fluid in the abdomen can reduce abdominal detail and give a 'ground glass' appearance. Patients that have suffered trauma, have abdominal masses or have a suspected coagulopathy should undergo thoracic radiography to rule out additional problems in the chest. Ultrasonography may be a more useful modality for imaging of a haemoperitoneum. Importantly, free abdominal fluid does not distort the image. Additionally, ultrasonography can be used to guide a needle for abdominocentesis. Serial abdominal ultrasound examinations have been used to determine whether there is ongoing abdominal haemorrhage.

Management

Patients with haemoperitoneum may have numerous presentations, depending on the disease process and rate of haemorrhage. Some patients are critical at presentation, while others are very stable. However, all haemoperitoneum cases should be treated very seriously. Typically, rapid therapeutic measures, including administration of intravenous crystalloids, colloids and blood products, should be initiated (see Chapter 4 and the *BSAVA Manual of Canine and Feline Emergency and Critical Care* for further information).

Oxygen support should always accompany resuscitation of a haemorrhaging patient. Severely anaemic patients lack adequate oxygen-carrying capacity, and 100% oxygen can be supplemented via a face cone, nasal catheter or oxygen cage to improve the partial pressure of oxygen. Surgery is indicated in patients with haemoperitoneum due to a bleeding splenic neoplasm. Suction should be used to clear the abdominal cavity, and the spleen, liver, kidneys and omentum should be checked thoroughly. Following identification of a bleeding splenic neoplasm, the spleen should be removed as efficiently as possible. Splenectomy is often complicated by the presence of omental adhesions (Figure 12.14). If possible, the omentum should not be peeled off the spleen; rather, it should be divided, ligated and removed concurrently.

12.14

Omental adhesions to a splenic haemangiosarcoma.

Postoperative considerations

After splenectomy, fluid therapy should be continued until the animal is haemodynamically stable and can maintain its own hydration. The PCV should be monitored and blood transfusions administered if indicated. Septic complications after splenectomy in dogs and cats are rare and antibiotic therapy can be discontinued postoperatively or within 24 hours in most animals.

Complications

Serious complications following splenectomy are rare. Haemorrhage secondary to ligature displacement is the most common complication. In a study by Brown *et al.* (1985), haemorrhage was the most common reason for immediate postsurgical death of dogs undergoing splenectomy for non-neoplastic conditions. Surgical intervention may be required with decreasing PCV, worsening clinical condition and evidence of blood in the abdominal cavity. Anaemia after splenectomy is often self-limiting in the presence of normally functioning bone marrow. Other infrequent complications include damage to the vasculature of the stomach or pancreas, which can cause ischaemic necrosis of those organs. In addition, pancreatitis may result from traumatic handling of the pancreas during surgery.

Cardiac arrhythmias

Cardiac arrhythmias have been reported in dogs following splenectomy, and a study by Marino *et al.* (1994) indicated that there is a high incidence of rapid ventricular tachycardia following splenectomy. Monitoring for ventricular arrhythmias is helpful; however, intermittent ECG monitoring is not reliable for detecting ventricular arrhythmias and continuous monitoring is recommended if possible. Ventricular arrhythmias can result in haemodynamic instability and potentially progress to fatal arrhythmias. Institution of anti-arrhythmic therapy should be performed if indicated (see Chapter 6 and the *BSAVA Manual of Canine and Feline Emergency and Critical Care*).

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OPERATIVE TECHNIQUE 12.1

Splenic biopsy and partial splenectomy

POSITIONING

Dorsal recumbency.

ASSISTANT

Useful but not essential.

EQUIPMENT EXTRAS

Topical haemostatic agent; large abdominal swabs; two large non-crushing forceps (i.e. Doyens); suction; electrocoagulation unit (optional); stapling equipment (optional).

SURGICAL TECHNIQUE

Approach

Perform a routine ventral midline abdominal incision from the xiphoid process to cranial to the pubis. Place a self-retaining retractor (e.g. Balfour retractor) to retract the abdominal wall and expose the abdominal viscera.

Surgical manipulations: splenic biopsy

During coeliotomy, biopsy of splenic lesions may be performed using a variety of techniques, including Tru-Cut needles or a Keyes punch biopsy. A topical haemostatic agent (see Chapter 2) may be beneficial in maintaining haemostasis.

Surgical manipulations: removal of focal lesions

- 1** For focal lesions near the centre of the spleen, make an oval incision through the capsule and into the parenchyma to an adequate depth to remove the lesion.
- 2** Close the splenic capsule by placing simple interrupted or mattress sutures of an absorbable 1.5 or 2 metric (4/0 or 3/0 USP) suture material.
- 3** For focal lesions near the splenic margins, use the overlapping mattress suture technique (see Operative Technique 9.1).

→ OPERATIVE TECHNIQUE 12.1 CONTINUED**Surgical manipulations: partial splenectomy**

- 1** Exteriorize the spleen and pack off with laparotomy swabs.
- 2** Define the area of the spleen to be removed.
- 3** Double ligate and incise the hilar vessels supplying the area. Note the extent of ischaemia that develops; this can be used as a guideline for the resection.
- 4** Squeeze the splenic tissue at the line of demarcation and milk the splenic pulp towards the ischaemic area using the thumb and forefingers.
- 5** Place forceps on the flattened portion and divide the spleen between the forceps.
- 6** Close the cut surface of the spleen adjacent to the forceps using an absorbable 1.5 or 2 metric (4/0 or 3/0 USP) suture material in a simple continuous pattern. Alternatively, two rows of mattress sutures in a continuous overlapping fashion can be placed across the line of demarcation. Any ongoing haemorrhage can be controlled by oversewing the end of the spleen with a continuous suture pattern or by using electrocautery.

Automatic stapling devices, such as a thoracoabdominal stapler, may also be used for partial splenectomy. The stapling device is placed across the spleen near the line of colour demarcation. It is important to place the double row of staples in the perfused, non-ischaemic portion of the spleen. Stainless steel staples 3.5 mm or 4.8 mm in size are recommended. Use of staples that are too long or too short may result in failure of the staples to hold and subsequent haemorrhage. In a study comparing stapling and ligation techniques for partial splenectomy, blood loss was equally low, as determined by clinical observation and comparison of PCV and total protein. Stapling techniques significantly decrease the surgery time. Other techniques that can be used to divide the splenic parenchyma include CO₂ lasers and ultrasonic cutting devices such as the Harmonic® scalpel (see Chapter 9).

Wound closure

Routine abdominal closure is performed.

The portion of spleen to be removed is identified and the transection line is visualized.

The vessels supplying the portion of the spleen to be removed are ligated and divided. Crushing forceps are placed across the tissue to be removed and atraumatic forceps (such as Doyen forceps) are placed across the remaining portion of the spleen. The spleen is then divided between the two pairs of forceps.

The cut surface of the spleen is oversewn with a continuous suture pattern. Alternatively, a double row of overlapping horizontal mattress sutures can be placed just proximal to the cut edge to ensure haemostasis.

POSTOPERATIVE MANAGEMENT AND COMPLICATIONS

See main text.

OPERATIVE TECHNIQUE 12.2

Splenectomy

POSITIONING

Dorsal recumbency.

ASSISTANT

Useful but not essential.

EQUIPMENT EXTRAS

Surgical suction to aspirate abdominal fluid or haemorrhage. Metal haemostatic clips or automated stapling devices may be useful for total splenectomy. The author routinely uses the a ligate-and-divide stapler (e.g. LDS™) for rapid ligation of smaller vessels.

SURGICAL TECHNIQUE

Approach

Ventral midline coeliotomy extending from the xiphoid process to the pubis.

Surgical manipulations

- 1 Thoroughly explore the abdomen for the presence of metastasis. In some cases a complete exploration may not be possible until the spleen has been removed.

Metastasis of a splenic haemangiosarcoma to the diaphragm.

Close-up view.

PRACTICAL TIP

A routine biopsy sample should be taken from the liver in any patient undergoing splenectomy because of the presence of a splenic mass. Although the presence of hepatic nodules may indicate metastasis in dogs with splenic masses, the hepatic nodules may also represent nodular hyperplasia

- 2 Exteriorize the spleen and pack off with laparotomy swabs.
- 3 Begin hilar vessel ligation with dissection and isolation of splenic vessels as they branch to enter the splenic parenchyma. This is usually started from the tail of the spleen, working carefully towards the head of the spleen.

→ OPERATIVE TECHNIQUE 12.2 CONTINUED

Curved forceps are used to dissect the vessels along the hilus of the spleen.

4 Double ligate the main branches of the splenic artery and vein with one circumferential and one transfixation ligature before transection to decrease the risk of postoperative haemorrhage.

5 Vascular occlusion can be achieved with absorbable or non-absorbable sutures or a variety of haemostatic clips:

- Metal haemostatic clips can supplement ligatures or be used as the primary method of vessel occlusion. A ligate-and-divide automatic stapling device places metallic clips on both sides of a pedicle and then cuts between them. This works especially well in dividing mesenteric or omental adhesions, but it is necessary to use well tied ligatures on vessels of substantial size. Haemostatic clips are appropriate for use on vessels up to 3 mm in size. A bipolar vessel-sealing device (e.g. LigaSure™) or Harmonic® scalpel, can be used to rapidly seal vessels, decreasing surgical time. Haemostatic clips or electro-surgical devices should not be used on the main splenic arteries and veins.

A ligate-and-divide stapler being used for a splenectomy.

The stapler has fired two C-shaped staples (arrowed) and divided between them.

Use of a ligate-and-divide stapler for complete splenectomy.

→ OPERATIVE TECHNIQUE 12.2 CONTINUED**PRACTICAL TIP**

Attention to ligature placement and careful application of vascular clips can reduce the likelihood of intra- or postoperative haemorrhage

- A faster technique for total splenectomy involves opening up the omental bursa and identifying the splenic artery and vein. These vessels or major branches can be double ligated and transected. It is important to identify and preserve the branches supplying the left limb of the pancreas when using this technique.

WARNING

This technique is often not possible in cases where splenic anatomy is grossly distorted owing to neoplasia or omental adhesion and it is safer to identify and transect vessels at the splenic hilus, rather than risk development of ischaemic pancreatitis

WARNING

In cases of chronic splenic torsion there can be significant fibrosis of the splenic pedicle, which can make identification of the vessels very difficult; however, mass ligation of the pedicle often fails to achieve adequate haemostasis and should be avoided

Wound closure

Routine abdominal closure is performed.

POSTOPERATIVE MANAGEMENT AND COMPLICATIONS

See main text.