Kafkas Univ Vet Fak Derg
26 (6): 841-848, 2020
DOI: 10.9775/kvfd.2020.24551

Kafkas Universitesi Veteriner Fakultesi Dergisi
ISSN: 1300-6045 e-ISSN: 1309-2251
Journal Home-Page: http://vetdergikafkas.org
Online Submission: http://submit.vetdergikafkas.org

Review

An Overlooked Entities in Small Animal Surgery: Splenic Disorders

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Article ID: KVFD-2020-24551 Received: 08.06.2020 Accepted: 11.10.2020 Published Online: 12.10.2020

How to Cite This Article

Özer K, Gümürçinler B, Karabağlı M: An overlooked entities in small animal surgery: Splenic disorders. *Kafkas Univ Vet Fak Derg,* 26 (6): 841-848, 2020. DOI: 10.9775/kvfd.2020.24000

Abstract

The spleen, which has a vitally important function in the body, is located in the left part of the abdomen. The spleen's primary tasks are hematopoiesis and immunity, such as the reservoir of blood cells and the production of the immune system's defense cells. On most occasions -due to the lack of clinical manifestation- splenic disorders are coincidental findings at surgery despite their prevalence. Splenosis is a heterotopic autotransplantation of splenic tissue in other body compartments, which may be interpreted as a pathological entity through imaging techniques. Foreign substance accumulation, such as iron deposition, namely siderosis, may be monitored in the spleen due to the aging process. The pathologies of the spleen are mostly characterized by the enlargement of the organ (splenomegaly). Hemangiosarcoma is the most frequently encountered neoplasia in the spleen, usually metastasizing to the heart's right atrium. Ultrasonography is the most commonly utilized diagnostic tool in splenic disorders. Besides, the magnetic resonance imaging (MRI) and computed tomography (CT) techniques may be applied. Whole blood, plasma, or both are prerequisites that should be kept at disposal in the preoperative approach to the splenic disorders. Surgical interventions of splenic pathologies include splenorrhaphy, partial splenectomy, and total splenectomy. Splenic injuries usually result from blunt trauma. Surgery is not an indication unless there is a life-threatening amount of blood loss. Splenic torsion, which is an acute disorder of the spleen usually encountered in deep-chested dog breeds due to gastric dilatation and volvulus presents a diagnostic challenge. Total splenectomy is the favored treatment of choice in the approach of the relevant conditions rather than splenic derotation. Early phase complications include hemorrhage, cardiac arrhythmia, and ischemia in the pancreas and gastric wall, and metastasis and gastric dilatation and volvulus appear as the complications of the postoperative course. This review has aimed to open a new gate to better understanding the importance and functions of the spleen in normal physiology and also aimed to share information about the diagnostic tools and guide through to apply appropriate surgical approach in term of disorders.

Keywords: *Splenosis, Hemangiosarcoma, Siderosis, Total splenectomy, Splenic torsion*

Küçük Hayvan Cerrahisinde Gözardı Edilen Bir Başlık: Dalak Hastalıkları

Öz

Vücutta hayati öneme sahip bir işlevi olan dalak, karnın sol kısmında yer alır. Dalağın birincil görevleri, kan hücrelerinin rezervuarı ve bağışıklık sisteminin savunma hücrelerinin üretilmesi gibi hematopoez ve bağışıklık olaylarıdır. Çoğu zaman -klinik belirtilerin patognomik olmaması nedeniyle- dalak hastalıkları, operasyon esnasında rastlantısal olarak tespit edilmektedir. Splenoz dalak dokusunun diğer vücut kompartmanlarındaki heterotopik bir ototransplantasyonudur ve görüntüleme esnasında patolojik bir durum olarak yorumlanabilir. Yaşlanma sürecine bağlı olarak dalakta demir birikimi yani sideroz gibi yabancı madde birikimleri izlenebilir. Dalağın patolojileri çoğunlukla organın genişlemesi (splenomegali) ile karakterizedir. Hemanjiyosarkom, dalakta en sık karşılaşılan neoplazidir ve genellikle kalbin sağ atriyumuna metastaz yapar. Ultrasonografi, dalak bozukluklarının tanısında en sık kullanılan tanı aracıdır. Ayrıca manyetik rezonans görüntüleme (MRG) ve bilgisayarlı tomografi (BT) teknikleri de kullanılabilir. Preoperatif dönemde tam kan, plazma veya her ikisi birden hazır edilmelidir. Dalak patolojilerinin cerrahi müdahaleleri arasında splenorafi, parsiyel splenektomi ve total splenektomi sayılabilir. Dalak yaralanmaları genellikle künt travmadan kaynaklanır. Yaşamı tehdit eden miktarda kan kaybı olmadıkça cerrahi müdehale endikasyonu doğmaz. Genellikle derin göğüslü köpek ırklarında mide dilatasyonu ve volvulusa bağlı olarak karşılaşılan ve akut bir dalak hastalığı olan dalak torsiyonun tanısı oldukça zordur. Bu durumda total splenektomi, dalak derotasyonundan ziyade tercih edilen tedavi seçeneğidir. Postoperatif erken dönem komplikasyonları, pankreas ve mide duvarında kanama, kardiyak aritmi ve iskemiyi içerir; postoperatif seyrin komplikasyonları olarak metastaz ve mide dilatasyonu ve volvulus görülür. Bu derleme, bir organ olarak dalağın fonksiyonel önemini ve işlevlerini daha iyi anlamak için yeni bir kapı açmayı, tanı araçları hakkında bilgiler paylaşmayı ve hastalıklarında uygun cerrahi yaklaşımın seçilmesine rehberlik etmeyi amaçlamıştır.

Anahtar sözcükler: *Splenoz, Hemanjiyosarkoma, Siderozis, Total splenektomi, Dalak torsiyonu*

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INTRODUCTION

Although the spleen is not an essential organ for survival, it cannot be considered unimportant. Accurate recognition of this organ, which has many tasks related to erythrocytes, platelets, and the immune system, is vital in small animal surgery, especially when evaluating traumatic and oncological disease. This review has aimed to open a new gate to better understanding the importance and functions of the spleen in normal physiology and also aimed to share information about the diagnostic tools and guide through to apply appropriate surgical approach in term of disorders.

ANATOMY AND PHYSIOLOGY OF THE SPLEEN

The spleen is a hook-shaped organ predominantly located in the left cranial part of the abdomen. It is situated parallelly in the left hypogastric region adjacent to the *curvature major* of the stomach. Particularly having been shrunk, it is a consistent organ, with a trabecular framework. Roughly, it has a tongue-like shape. Once the spleen has enlarged, it gets extended and the trunk of the organ contracts. It has a triangular shape on the sections [1]. The organ's color was defined as purple-red, red-brown, amaranth, mahogany, and grey-brown [2, 3]. Its shape, size, and location vary depending on several parameters such as the species, breed, medication, and the pathologic translocation of the organ. The spleen's portion occupying the thorax varies depending on its contraction capacity and gastric fullness [4].

When contracted, the spleen might thoroughly translocate into the thoracal cavity and appears pale bluish-purple. On the contrary, when congested, the caudal portion of the spleen might advance to the urinary bladder and appear dark brownish-red. A cat spleen is narrower and smaller compared to the dog spleen [4]. The *celiac* artery, which is originated from the abdominal aorta and branches into three segments such as the hepatic, left gastric and splenic artery, nurtures the spleen [5]. Blood enters the spleen through the splenic artery as a branch of the *celiac* artery into the gastrosplenic vessel and exists through the splenic vein that finally opens into the portal vein. Short gastric arteries arising from the splenic artery anastomose with the branches of the left gastric artery [1]. The splenic artery supplies blood from several hilar vessels and connects with the gastrosplenic vessel before entering the portal vein. Splenic lymph nodes are situated adjacent to the artery merely a few centimeters away from the spleen and the hilus [2]. A normal spleen is soft and consistent, yet not friable as the liver. The spleen constitutes approximately 0.2 % of the body weight in small animals [5].

The spleen is supported by the portion of the *omentum major*, which leaves the left *cupola* of the diaphragm located between *esophageal hiatus* and *celiac* artery and *frenicosplenic* ligament. This portion of the omentum is enlarged in the caudal direction and having to cover the splenic hilus initially, and then the *curvature major* of the stomach emerges as a broad *gastrosplenic* ligament [1]. The spleen is composed of a capsule, rich in elastic and smooth muscle fibers, trabeculae, and parenchyma of red and white pulp. Trabeculae form a spider net-like tangled structure. Some trabeculae join and reinforce the blood vessels, while other blood vessels are self-contained [6]. Larger intrasplenic arteries are mainly situated within the trabeculae. Collagenous fibers of trabeculae directly proceed to reticular fibers in the white pulp [1]. The white pulp of the dog is composed of widespread nodular lymphoid tissue. The nodules are usually smaller than 1 mm in diameter and are not visible to bare eyes. Their germinal centers appear paler than the peripheral pulp. The red pulp is composed of splenic cords, which form a spongy network filled by venous sinuses. The cellular component of splenic cords includes abundant lymphocytes, megakaryocytes, mobile and resident macrophages, and circulating blood cells, the majority of which comprise agranulocytes [7].

Intrauterine malformation or malfunctioning of the spleen is called "asplenia" [8]. Accessory splenic nodules widely found on the omentum of small animals represent revascularized tiny splenic tissue portions that possibly occurred secondarily to trauma [9]. Ectopic splenic tissue embedded alongside the pancreas' surface as nodules were found only in cats; however, its cause was not conclusively linked with trauma. Siderotic and siderofibrotic plaques may be found on a geriatric dog spleen as amorphous calcium and iron deposits [2]. Splenosis is a benign condition that emerges as a result of trauma or rupture occurred during a surgical intervention. It is usually a coincidental finding and is not considered an indication for treatment unless symptomatic. Moreover, it may radiographically mimic a malignancy, which should be thoroughly examined. The diagnostic method of choice is nuclear scintigraphy in relevant cases. Splenosis is usually detected in the abdominal and pelvic cavity, yet intrathoracic, subcutaneous, intrahepatic, and intracranial lesions were defined in the patients [4].

The spleen's size and weight in cats and dogs vastly vary since it serves as a significant blood reservoir in the body. The contracted spleen after exercise, due to the smooth muscle fibers found throughout the organ rhythmically relax in the resting position. These smooth muscle fibers relax with anesthetic administration, which results in prominent splenomegaly. Catecholamines, stress, and injections lead to the removal of mobile blood cells and the plasma from the red pulp, and thus the spleen shrinks. No parasympathetic nerve fibers are found in the spleen. Splenic rupture may be detected due to a traumatic impact that occurred during traffic accidents, yet it is highly likely possible to remove the organ with no life-critical complication surgically. The respectively loose bond of

the spleen with the stomach facilitates splenectomy on a vascular basis [10].

SPLEEN DISORDERS

Splenomegaly

A preliminary clinical examination includes spleen's size, whether it is enlarged (splenomegaly) or shrunk. Splenomegaly may result from congestion and some other infiltrative diseases. The cut surface of a congested spleen readily emits the blood, yet an infiltrated spleen is more consistent restraining the blood [11].

Splenitis and Inflammation

Splenitis refers to an inflammatory accumulation, which may further be categorized according to the predominant cell component. Bacteria, viruses, fungi, and protozoal agents may cause splenitis [12]. The most frequent causes of uniform splenomegaly in the dog include bacteriemia, hypothermic sepsis, and contagious chronic diseases, in which necrotic residues are filtrated through the spleen. On certain occasions, neutrophilic infiltration that might have advanced with a localized abscess predominates an infectious splenitis. Eosinophilic splenitis may accompany the course of the disease in cats with hypereosinophilic syndrome and dogs with eosinophilic gastritis along with other clinical signs. Pyogranulomatous splenitis was demonstrated in feline infectious peritonitis [13]. Lymphoplasmacytic infiltrative splenomegaly may be monitored as chronic or subacute forms accompanying mycotic and mycobacterial infections. Necrotizing splenitis results from gas-producing bacteria. Splenic vascular thrombosis is simultaneously detected with hypercoagulative pathologies resulting from the *Clostridia spp* growth in the hypoxic areas. Blood flow and thus, oxygen transportation is abundant in both the red and white pulp hampering the growth of coagulative infectious agents; therefore, necrotizing splenitis is rare in cats and dogs [4].

Congestion

Splenic torsion is commonly encountered in the pig and dog, including the concurrent translocation of the spleen and stomach, particularly in deep-chested breeds. Unlike ruminants, the spleen of pig and dog is loosely bound with the stomach through a gastrosplenic ligament. Splenic torsion leads to splenic infarction by an initial clogging of the blood vessels and then blocking blood flow in the spleen and finally, the occlusion of the main splenic artery. The spleen turns on a bluish-black color with a prominent, yet regular enlargement, usually rendering a "C" shape overlapping the medial surfaces, which is considered an indication for surgery. The majority of the surgeons recommend a direct removal of the spleen without derotation to prevent thrombosis and the release of endotoxins and free radicals [14].

Intravenous injection of barbiturates causes acute congestion in the spleen. Drug-induced splenomegaly is detected due to the administration of phenothiazines such as acepromazine, barbiturates, and short-acting barbiturates such as thiopental. It was shown in a study that splenomegaly was more likely induced by thiopental and ketamine-diazepam combination than propofol-based anesthesia protocols. Causes of congestive splenomegaly include portal hypertension, right heart failure, and splenic torsion [10].

Immune-mediated Reactions and Hyperplasia

Generalized splenomegaly may physiologically arise from the overproduction of the spleen's cellular component while functioning normally. Red pulp and white pulp hyperplasia or both may occur in animals suffering from chronic diseases. Subacute and chronic disorders, such as immune-mediated hemolytic anemia and thrombocytopenia, usually lead to red and white pulp hyperplasia. Splenomegaly is widespread in dogs with immune-mediated hemolytic anemia, which might have resulted from extramedullary hematopoiesis and reticuloendothelial hyperplasia associated with the destruction of IgG coated erythrocytes. Macrophage hyperplasia induced by increased phagocytic activity initially affects the red pulp and is usually detected in histoplasmosis and leishmaniasis. Acute hemolytic anemia, babesiosis and immune-mediated hemolytic anemia may cause prominent congestion in the spleen. A large number of circulating phagocytized erythrocytes and their accumulation lead to the congestion of the spleen [11,15-19].

Infection Associated Disorders

Splenic infiltrations may occur due to bizarre cell accumulation or substance depositions during neoplastic processes (primary and metastasizing) and splenic amyloidosis, which is a rare condition. Neoplasia-associated splenomegaly usually results from the neoplastic proliferation of the resident cells such as lymphocytes, macrophages, fibroblasts, smooth muscle, and endothelial cells, which emerges as primary neoplastic lesions. The most common cause of generalized splenomegaly is myeloproliferative neoplasias, such as lymphosarcoma and mastocytosis [4]. Metastasis to the spleen is an uncommon finding and usually appears as focal solitary or multifocal lesions. Lymphoma is the most frequently detected metastasizing lesion in the spleen [19]. Rarely, certain lysosomal storage diseases and splenic amyloidosis may lead to generalized splenomegaly. The spleen appears as a pale beige firm and waxy tissue in dogs with splenic amyloidosis [4].

Localized Splenomegaly

Localized splenomegaly may result from neoplastic and non-neoplastic entities. The most common causes of localized splenomegaly are addressed as nodular hyperplasia, splenic hematoma, and hemangiosarcoma [4].

Splenic Hematoma

Hemorrhage in the red pulp is a prerequisite for splenic hematoma, restricted within the splenic capsule of an approximate diameter of 12-15 cm, red to dark red with a soft consistency. Coagulation mechanisms, transforming blood into dark reddish-brown pulpy material, macrophage infiltration to phagocytize erythrocytes, and degraded hemoglobin are the constituents of splenic hematoma, which takes days to weeks to develop. The indeed repairing process elicits hematoidin and hemosiderin, and thus fibrosis in the spleen. On certain occasions, the splenic capsule that covers the hematoma may rupture, damaging the visceral peritoneum, resulting in hemoperitoneum, hypovolemic shock, and death. The causes of hematoma are not precisely recognized. Some may develop due to trauma, while some others result from splenic nodular hyperplasia. Splenic hematomas were reported to have occurred due to the rupture of hemangiosarcomas located within the spleen [11].

Hamartoma

Canine splenic hamartomas are rare benign lesions resulting from the mature splenic residential cells and tissues' overgrowth as in nodular hyperplasia [20]. Furthermore, hamartomas may be differentiated by not mimicking the surrounding tissue. Despite the lack of specific diagnostic data, these entities are highly likely differentiated from the other forms of localized splenomegaly merely on ultrasonography. Computed tomography (CT) and magnetic resonance imaging (MRI) techniques, widely applied in human medical practice, are more reliable diagnostic tools to differentiate hamartomas from other miscellaneous benign proliferation [4].

Nodular Hyperplasia

Nodular hyperplasia, formerly referred to as "splenoma" is a prevalent, yet coincidental splenic pathology in geriatric dogs. The nodules, which are composed of clusters of lymphoid, erythroid, and myeloid cells, and megakaryocytes, are known to be benign lesions. On the other hand, some authors reported that nodular hyperplasia might have advanced to a hematoma due to the peripheral circulation's failure that caused accumulation of abundant blood within the nodules. Splenic hematomas and hyperplastic nodules, which histologically differ, might be permanent lesions in dogs. Non-sinusoidal nature of the feline spleen is not prone to venous congestion hampering the occurrence of nodular hyperplasia, a rare entity in the cat [21].

Acute Splenic Infarctions

Splenic infarctions are triangular-shaped hemorrhagic lesions that initially occur at the periphery of the organ. Splenic infarctions usually result from hypercoagulative diseases, such as liver and kidney disorders, Cushing syndrome, as well as neoplastic lesions and cardiovascular disease in the dog. It may be highly unlikely to demonstrate the splenic infarction precisely in the early phases, yet it may develop into a wedge-shaped lesion with its baseline situated toward the capsule, which appears as a separate dark-red swollen tissue. The lesion turns into a grey-white focus in the chronic lesions and shrinks due to fibrosis [11].

Pseudotumors

Inflammatory pseudotumors are rare entities both in dogs and humans; therefore, they should be separately assessed in the differential diagnosis of nodular hyperplasia and some malignant tumors, such as lymphoma and sarcoma. The prognosis is favorable in humans after splenectomy [22].

Hemangiosarcoma

Hemangiosarcoma is a malignant neoplasm, which is a widespread primary tumor of the spleen in dogs. On the other hand, benign splenic hemangiomas are quite rare. Hemangiosarcomas may appear as solitary, multifocal, dark reddish-purple tumors that are not easily differentiated from hematomas. The cut surface may appear as sanguineous pulpy red tissue, while the tumor may be firm and pale in the solid areas. Metastasis may develop in the early phases. Multiple reddish-black masses on the omentum, abdominal organs, and the serosa manifest metastasis to the abdomen. Metastasis to the liver and the lungs is prevalent through the hematogenous route. In dogs, hemangiosarcomas were previously defined in the heart's right atrium, retroperitoneal adipose tissue, and the skin, while hemangiosarcomas with multiple organ involvement were identified in horses, cats, and cattle. Usually, since hemangiosarcomas have already metastasized on the initial diagnosis, the primary tumor is unlikely to be defined [11].

Hemangioma

Benign hemangiomas are demonstrated in the vast majority of dogs with localized splenomegaly. The relevant entities are solitary masses composed of well-differentiated endothelial cells [11]. The defined tissue structure enables hemangiomas to be easily differentiated from hemangiosarcomas, forming irregular, amorphous masses of neoplastic endothelial cells and vascular spaces. Nevertheless, hemangiomas, hematomas, and hemangiosarcomas reveal similar images in the dog [4].

Parasites

Cystic parasitic nodules may be encountered on the spleen, usually intermediate forms of *Echinococcus granulosus* and *Cysticercus tenuicollis*, prevalent in wild animals [11].

Splenic Abscess

Splenic abscess, which usually arises from pathologies

impairing the vascular network and lymph drainage of the spleen, is rare in small animals [23]. Certain microorganisms cause chronic suppurative splenitis, which typically ends up in splenomegaly [4].

Plaques

Siderocytic plaques commonly seen on the spleen's surface as golden and black spots are non-malignant lesions, which is an outcome of a hemorrhage resulting from erythrophagocytosis subsequently occurring with hemoglobin breakdown. Siderocalcific plaques, which appear as yellowish-white crusty depositions at the edges or within the parenchyma of the spleen, are considered a natural outcome of the aging process in geriatric animals, yet on certain occasions; it may be linked with trauma [11].

Exceptional Conditions: Splenic Torsion

Splenic torsion has never been identified in the cat, yet is a rare disorder of the dog's spleen. Deep-chested dog breeds and males are more prone to develop splenic torsion [20,24-26]. Splenic torsion initially obstructs the venous circulation, which leads to splenic congestion, followed by arterial occlusion in further phases, which ends up in splenic infarction. Even though pathogenesis is unclear, splenic torsion is assumed to have concurrently occurred with gastric dilatation and volvulus. Clinically, chronic splenic torsion is manifested by lethargy, anorexia, vomiting, diarrhea, polyuria, polydipsia, and weight loss, which intervene with those of other disorders causing abdominal pain, hampering a differential diagnosis. Dogs with acute splenic torsion may show clinical signs of evidence of hypovolemic and toxic shock. Hematological findings are interpreted as leukocytosis, anemia, and thrombocytopenia on hemogram. Biochemical changes comprise elevated hepatic and pancreatic enzymes lacking peculiarity. Treatment of choice in the patients with splenic torsion includes palliative care and splenectomy. Derotation of the spleen is not considered an option since it might result in the intravascular release of sequestered blood components, thrombus and microthrombus particles, free radicals, and cytokines such as tumor necrosing factor and vasoactive amines into the systemic circulation. Emergency splenectomy should be performed in acute cases [4].

DIAGNOSIS

Diagnostic Radiography

It is an effortless process to image the spleen in dogs and cats radiographically, yet its location may differ by the movable caudal portion of the organ. A standard ventrodorsal shooting reveals a transversal triangular-shaped section of the spleen's cranial extremity extending from the left cranial region to gastric fundus caudolaterally, and the left kidney craniolaterally. The canine spleen is more visible with the right lateral imaging [27,28]. Large splenic masses are usually visualized on the abdominal midline and lateral regions. Generalized splenomegaly is characterized by round or blunt splenic edges. Hemoabdomen that emerge from splenic hemorrhage and rupture may fade in visceral radiographical details hampering the imaging of splenic and hepatic silhouettes [4].

Ultrasonography

Ultrasonography is the most preferred diagnostic tool for assessing the spleen and the metastasized masses in the abdominal cavity [25]. Contours of the spleen should be carefully evaluated during ultrasonography in terms of potential traumatic alterations, hematoma, and different types of focal expansions and irregularities due to neoplastic lesions. The spleen's size should be assessed, yet there are no standard maximum and minimum values established concerning the spleen's size in dogs and cats. Therefore, an experienced eye plays a crucial role in interpreting the ultrasonographic findings. It is highly unlikely to monitor a physiological enlargement in the cat spleen due to the feline spleen's non-nervous nature [26]. Hypoechoic nodules within the spleen are mostly associated with infiltrations, infarction, and necrosis, while widespread hypoechoic parenchyma is usually observed with splenic congestion and torsion.

Hematomas, neoplasms, abscesses, and cysts may appear as cavitary lesions by ultrasonography. Doppler ultrasonography is used to assess the characteristics of the focal and multifocal splenic lesions in cats and dogs [29,30]. While ultrasonography is utilized as a diagnostic tool for splenic disorders, a throughout abdominal examination concerning potential effusions, lymphadenopathy, hepatic abnormalities, and masses is of great importance. Right atrial hemangiosarcoma may concurrently be found in 25% of the dogs with splenic hemangiosarcomas, which points out the necessity of cardiac Doppler ultrasonography before surgical intervention [4].

Computed Tomography (CT) and Magnetic Resonance Imaging (MRI)

Computed tomography and MRI have become vastly utilized techniques also in veterinary medicine to image splenic disorders. Both techniques have long been routinely applied in human medicine, particularly to assess a concurrent underlying disease [31-33]. A recent prospective study investigating the splenic lesions by contrast CT revealed a reduced density for hemangiosarcomas than nodular hyperplasia and before and after contrast scans of hematomas [34].

SURGERY

Preoperative Management

Generalized and focal splenomegaly or both might be

monitored in the animals with splenic disorders requiring surgical intervention. Widespread (symmetrical) splenomegaly may result from congestion (i.e., splenic torsion, right cardiac failure, gastric dilatation/volvulus [GDV], and drugs), infiltrations due to infection (i.e., mycotic, bacterial, and rickettsial), foreign bodies, immune-mediated diseases (i.e., immune-mediated thrombocytopenia and immune-mediated hemolytic anemia), and neoplasms (i.e., lymphosarcoma, histiocytic sarcoma, and feline mastocytosis). Benign lesions (i.e., nodular regeneration, hematoma, and trauma) and neoplastic entities (i.e., hemangiosarcoma and lymphoma) may cause focal splenomegaly. Neoplasia-associated infiltrative splenomegaly is the most common cause of spontaneous splenomegaly in dogs and cats. Anemia, splenic trauma, rupture of a hematoma, and underlying diseases (i.e., chronic infections and disseminated coagulopathy [DIC]) might have induced a hemorrhage. Coagulation factors should be measured in the animals with non-traumatic splenic hemorrhage. Whole blood and plasma or both should be at disposal before splenectomy. In case DIC is suspected, treatment protocols should include heparin. Dehydrated animals should be parenterally treated before the surgical procedure, and preoxygenation should be applied for anemic animals, which should be maintained even in the recovery period. The choice of perioperative prophylactic antibiotics is crucial in the dog to be performed splenectomy. Perioperative antibiotic administration is unnecessary in healthy animals, yet it might be applied during the induction of anesthesia and should be ceased in 24 h. Immunosuppressed and cachectic animals may require a more extended antibiotic application. It was reported that splenectomy performed along with dental detartrage and extraction might have resulted in multiple abscesses, septicemia, and even death in the dog [4].

Surgical Techniques

Splenorrhaphy

Small iatrogenic lacerations or perforations are indications for splenorrhaphy, yet maintaining hemostasis is vitally important. If there is hemorrhage, a capsular repair might be considered at appropriate pressure by appropriate technique [4]. Trauma-associated splenic rupture or laceration may spontaneously heal without the requirement of splenorrhaphy or splenectomy [25].

Partial Splenectomy

Partial splenectomy is a more challenging technique than total splenectomy, yet it allows the spleen's physiological function to be maintained. The procedure is an indication for focal splenic abscess or injuries; however, it is out of the question in neoplastic lesions. Partial splenectomy is most commonly performed on animals with blunt or penetrated abdominal trauma that has impaired the vascular structure of the spleen [35-37].

Total Splenectomy

Total splenectomy is an indication for animals with definitive or suspected neoplastic lesions, splenic torsion, severe trauma, widespread infiltrative diseases, and with some immune-mediated diseases [4]. Total splenectomy is most commonly performed on animals with a history of splenic neoplasms, gastric dilatation/volvulus, and severe trauma manifested by a life-threatening hemorrhage. Splenectomy was previously applied for non-responsive hematologic disorders (i.e., thrombocytopenia and hemolytic anemia); however, immunosuppressive drugs and corticosteroids extenuated the requirement for the procedure. Nevertheless, it might be considered if the medication has failed or generated intolerable side effects. Even though sepsis has been reported after splenectomy in humans, there is no known case in dogs, yet -if possible- partial splenectomy should be preferred rather than total splenectomy. Splenectomy is contraindicated in patients with bone marrow hypoplasia since it is the leading site for hematopoiesis [38,39]. It is not uncommon for veterinary practitioners to recommend prophylactic gastropexy for large breed dogs that underwent splenectomy to prevent potential gastric dilatation and volvulus [4].

POTENTIAL COMPLICATION OF SURGICAL INTERVENTIONS

Hemorrhage

Acute blood loss may be detected after splenectomy, which might have been resulted from unsuccessful surgical intervention and hemostatic anomalies. Incomplete ligation of omentum vessels, loosely inserted surgical clips and inaccurate electrocautherization may cause hemorrhage. Potential causes that may result in hemorrhage after splenectomy may be listed as autoimmune disorders that lead to endothelial injury, thrombocytic activation or breakdown, splenic masses, infection, and trauma [31-34]. It has been reported that a thrombocyte count of 25.000/µL allows a safe splenectomy [33]. According to a published study, DIC is more likely to have developed in dogs with malignant tumoral lesions when the activated partial thromboplastin time (aPTT) has prolonged [34].

Cardiac Arrhythmia

Arrhythmia causes reduced cardiac output. It usually occurs as ventricular tachycardia or multifocal ventricular arrhythmia, which is monitored in dogs with splenomegaly due to malignant tumors, torsion, and benign tumoral masses after splenectomy [35-37].

Ischemia on the Left Lobe of the Pancreas and Gastric Wall

Left pancreatic ischemia results from the occlusion of the pancreatic and splenic blood vessels, which might

emerge as a life-threatening condition. Potential risks include splenic torsion, splenic tumors causing secondary DIC or coagulation disorders, and defective surgical manipulations [35-37].

Metastasis

Hemangiosarcoma is a commonly encountered entity in the spleen [31-33]. Recent studies have been aimed at the differentiation of benign entities from malignant splenic lesions. However, the studies turned out to be inconclusive. Multifocal lesions may be attributed to metastasis. Some neoplasms (i.e., lymphoma, mast cell tumor) may be primary or secondary lesions on the spleen [38-42].

Gastric Dilatation and Volvulus

Gastric dilatation and volvulus (GDV) is a risky condition with a potentially dangerous outcome, in which the stomach rotates around its axis and, most frequently, in a clockwise fashion. A recent study demonstrated that splenectomized patients with GDV had a poorer prognosis than those that underwent only a derotation procedure [42-45]. The relevant findings favor considering a prophylactic gastropexy in splenectomized dogs, particularly bearing other risk factors for developing GDV [45-49].

CONCLUSION

Splenic disorders and their surgical treatment are currently becoming more prominent in veterinary medicine as in their human counterparts. The developing technology enables the widespread utilization of advanced imaging and surgical techniques in assessing and treating splenic disorders. Since splenic pathologies do not reveal prominent clinical signs, they are prone to be overlooked by veterinary practitioners. Instant intervention in acute cases like splenic torsion might have a life-saving outcome.

Statements of Authors Contributions

All authors contributed to the content and main topics of the manuscript. Introductions, anatomy and physiology prepared by MK, spleen disorders prepared by BK and diagnosis, treatment and complications prepared by KÖ. Final controls made by KÖ.

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