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Farhana Sultana
Department of Veterinary Medicine, Faculty of Veterinary and Animal Sciences, West Bengal University of Animal and Fishery Sciences, Kolkata, West Bengal, India

Amit Raj Gupta
Department of Veterinary Medicine, Faculty of Veterinary and Animal Sciences, West Bengal University of Animal and Fishery Sciences, Kolkata, West Bengal, India

Samar Sarkar
Department of Veterinary Medicine, Faculty of Veterinary and Animal Sciences, West Bengal University of Animal and Fishery Sciences, Kolkata, West Bengal, India

Chandan Lodh
Department of Veterinary Medicine, Faculty of Veterinary and Animal Sciences, West Bengal University of Animal and Fishery Sciences, Kolkata, West Bengal, India

Debaki Ghosh
Department of Veterinary Surgery and Radiology, Faculty of Veterinary and Animal Sciences, West Bengal University of Animal and Fishery Sciences, Kolkata, West Bengal, India

Subhasis Batabyal
Department of Veterinary Biochemistry, Faculty of Veterinary and Animal Sciences, West Bengal University of Animal and Fishery Sciences, Kolkata, West Bengal, India

Kumar Saurabh
Department of Veterinary Medicine, Faculty of Veterinary and Animal Sciences, West Bengal University of Animal and Fishery Sciences, Kolkata, West Bengal, India

Ankur Upadhyay
Department of Veterinary Medicine, Faculty of Veterinary and Animal Sciences, West Bengal University of Animal and Fishery Sciences, Kolkata, West Bengal, India

Corresponding Author:
Farhana Sultana
Department of Veterinary Medicine, Faculty of Veterinary and Animal Sciences, West Bengal University of Animal and Fishery Sciences, Kolkata, West Bengal, India

Haematological profile of dogs with hepatic disorders

Farhana Sultana, Amit Raj Gupta, Samar Sarkar, Chandan Lodh, Debaki Ghosh, Subhasis Batabyal, Kumar Saurabh and Ankur Upadhyay

Abstract
The study was undertaken in 9925 clinical cases presented to the Teaching Veterinary Clinical Complex, West Bengal University of Animal and Fishery Sciences, Belgachia, Kolkata. The diagnosis was done using preliminary examination and confirmed with radiography and ultrasonography. A group of 10 healthy control dogs were studied for the trial. 72 (0.73%) dogs were diagnosed with hepatic disorders. Dogs with clinical signs showing inappetance, vomiting, yellowish tinge in skin and mucus membrane, depriciating body condition, diarrhoea, anorexia, weight loss, pale mucus membrane, hepatomegaly, abdominal pain, ascites, constipation, pyrexia, darker color of urine, polydipsia and polyuria were considered for the study. Anaemia was a constant occurence among the haematological findings. Dogs with hepatic disorders showed decrease in lymphocyte and platelet count. Total leucocyte, monocyte, eosinophil and neutrophil count showed increase in the patients.

Keywords: dogs, anaemia, hepatic disorder, liver, haematology

1. Introduction
Globally, thirty three percent of the households have dogs as pets. As the times are changing, more and more of these pets are seen to have been acquiring various forms of ailments that could be directly or indirectly associated with their modernized life style. One of these ailments is the insufficiency in functioning of the organ "Liver". 5% of the non communicable diseases that occur in dogs are liver diseases. 70% of these diseases again are chronic diffuse liver diseases (Belza *et al.*, 2017; Popova *et al.*, 2020; Smirnova *et al.*, 2018; Vatnikov *et al.*, 2019 and Watson and Bunch, 2009) [1, 27, 37, 49, 54]. Liver disorders are responsible for 14.17% cases of anaemia reported among domestic dogs (Panchal *et al.*, 2022) [24].

2. Materials and Methods
The present investigation was carried out in the Department of Veterinary Medicine, Ethics and Jurisprudence, Faculty of Veterinary Science, West Bengal University of Animal and Fishery Sciences, Kolkata from 15th September, 2019 to 15th March, 2022. Ten apparently healthy dogs presented to the Veterinary Clinical Complex (Belgachia) were considered as controls. These animals had been presented with complaints of lethargy, weakness, yellowish skin, mucus membrane and eyeball coloration, pale or whitish mucus membrane and gums, vomition, diarrhea, constipation, inappetance leading to anorexia, melena, distended abdomen, yellowish urine coloration, polydipsia, polyuria, dehydration represented by sunken eyeballs and congested mucus membranes and gradual weight loss. Dogs with these symptoms were however exempted from the study if they were tested positive for any kind of bacterial, viral or protozoal infection or parasitic infestation of the gut. For confirmatory diagnosis, the suspected cases were subjected to radiography and ultrasonography.

2.1 Haematological examination
Blood was collected from the healthy control as well as ailing dogs using disposable syringes. Two mililitres of whole blood was collected from the saphenous or cephalic vein of the dog in vacutainers containing disodium salt of ethylene diamine tetra acetic acid (Na_2EDTA) as anticoagulant for evaluation of haematological parameters like RBC (red blood corpuscles count), MCV (mean corpuscular volume), Hct (haematocrit), MCH (mean corpuscular haemoglobin), MCHC (mean corpuscular haemoglobin concentration), Hb (haemoglobin), Lymphocytes, Plateletes, TLC (total leucocyte count), Neutrophils, Monocyte and Eosinophil using the technique suggested by Jain, 1986 [15].

2.2 Statistical analysis
Data were analyzed by one-way analysis of variance (ANOVA), with post hoc analysis using Duncan's multiple comparison tests using SPSS 20.0 software and expressed as mean ± SE with $p<0.05$ considered statistically significant (Snedecor and Cochran, 1994).[38]

3. Results and Discussion

Table 1: Comparison of mean +/- SE values of haematological parameters between healthy control and diseased dogs

Parameter	Healthy dog (n = 10)	Diseased dog (n = 72)
Haemoglobin (g/dL)	12.74 ± 0.15	09.71* ± 0.43
RBC (mil/mm^3)	6.13 ± 0.17	03.65* ± 0.14
MCH (fl)	21.12 ± 0.70	27.24* ± 1.60
HCT (%)	51.54 ± 0.80	24.88* ± 0.90
MCV (fl)	80.41 ± 2.81	69.18* ± 2.72
MCHC (g/dL)	26.50 ± 0.83	40.21* ± 2.64
Lymphocyte (%)	33.89 ± 0.63	24.68* ± 0.43
Plateletes (10^3/µL)	2.34 ± 2.65	152.16* ± 4.38
TLC (10^3/mm^3)	12.50 ± 0.10	15.58* ± 0.46
Neutrophil (%)	63.00 ± 0.57	70.27* ± 0.45
Monocyte (%)	1.62 ± 0.50	3.38* ± 0.08
Eosinophil (%)	1.52 ± 0.07	1.66 ± 0.04

(*significant at $p<0.05$)

The haematological parameters of the dogs with hepatic disorders were compared with those of the healthy control group in table 1. It was observed that haemoglobin, RBC, HCT, MCV and lymphocytes were seen to be significantly ($p<0.05$) lower in the diseased dogs compared to the healthy dogs. However, the levels of MCH, MCHC, platelets, TLC, neutrophil and monocyte were found to be significantly ($p<0.05$) higher compared to the healthy control group. Eosinophil level however did not vary significantly in the two groups.

The presence of anaemia is a prominent feature of cases reported to have hepatobiliary disorders (Sharma *et al.*, 2001; Tiwari *et al.*, 2001; Vijayakumar *et al.*, 2004; Shrivastava *et al.*, 2010; Chaturvedi *et al.*, 2013; Kumar *et al.*, 2013; Telagar, 2017; Lakshmi *et al.*, 2018 and Bhatti, 2020) [35, 47, 50, 36, 6, 18, 44, 19, 2]. This anaemia could be explained as lack of feed intake indicating inappetance and anorexia. The inefficient use of stored iron is presented as a possible explanation of anaemia (Watson and Bunch, 2009) [53]. Besides, hepatobiliary diseases also result in mild suppression of bone marrow and it stands as another possible explanation of the anaemia (Dial, 1995) [10].

Dogs with liver disorder show decrease in RBC level (Patnaik *et al.*, 1980 Thusara *et al.*, 2006; Vijayakumar *et al.*, 2008; Sumathi, 2012; Tantary *et al.*, 2014; Saravanan *et al.*, 2014**;** Pradeep *et al.*, 2017; Sumathi *et al.*, 2017; Lakshmi *et al.*, 2018 and Bhatti, 2020) [26, 46, 51, 39, 43, 33, 28, 40, 19, 2]. The liver being an organ with a crucial role in lipid metabolism – the insufficiency of liver functions causes lipid disturbances in cell membranes. The rise in the amount of cholesterol in the erythrocyte cell membrane results in the enlargement of its surface – the effect of "macrocytosis" on complete blood count (Morse, 1990) [23] and (Dawidowski and Pietrzak, 2022) [9].

Alteration in haematocrit levels are a feature of anaemia due to hepatic insufficiency (Tripathi, 2008; Sarma *et al.*, 2009; Sumathi, 2012; Tantary *et al.*, 2009; Lathamani and Nalinikumari, 2015; Elhiblu *et al.*, 2015; Pradeep *et al.*, 2017; Sumathi *et al.*, 2017 and Prebavathy *et al.*, 2020) [48, 34, 39, 43, 20, 11, 28, 40, 30]. The low PCV could be derived as an outcome of hypocellular bone marrow and pancytopenia representing aplastic anaemia (Gonzalez-Casas *et al.*, 2009) [14].

Dogs with hepatic disorders show increase in MCV levels (Burrows and Taboada, 2009; Saravanan *et al.*, 2014**;** Elhiblu *et al.*, 2015; Taboada, 2016; Tandel *et al.*, 2019 and Gogulski *et al.*, 2021) [5, 33, 11, 41, 42, 13]. A high MCV is indicative of macrocytic anaemia in patients with incompetent liver as it reflects on the deficiency of vitamin B12/ folic acid. Liver disorder can possibly lead to malabsorption of vitamin B12/ folic acid resulting in bone marrow showing megaloblastic erythropoiesis (Gonzalez-Casas *et al.*, 2009) [14].

Increase in MCH is a common occurrence in dogs with liver disorders (Sumathi, 2012; Saravanan *et al.*, 2014 and Elhiblu *et al.*, 2015) [39, 33, 11]. An increase in MCV levels with variable MCH and MCHC levels indicate macrocytic anaemia as a result of deficiency of vitamin B12/ folic acid. This could be explained by the fact that the liver acts as the organ of absorption and reabsorption of vitamin B12 and folic acid (Gonzalez-Casas *et al.*, 2009) [14].

MCHC levels increase in animals with hepatic disorders compared to healthy dogs (Saravanan *et al.*, 2014; Elhiblu *et al.*, 2015; Tandel *et al.*, 2019 and Gogulski *et al.*, 2021) [33, 11, 42, 13]. In liver diseases, there may be increased deposition of cholesterol on the membrane of circulating RBCs. This deposition increases the surface area of the erythrocyte. This could reflect as increased levels of MCHC in cases of liver disorder (Yang *et al.*, 2018) [57].

These alterations in lymphocytes are explained as a secondary to liver damage in all conditions affecting the liver (Parker, 2002; Pradhan, 2008; Sumathi, 2012; Saravanan *et al.*, 2014 and Thomas *et al.*, 1976) [25, 29, 33, 45].

In hepatic disorders, decrease in platelet count is observed comared to healthy controls (Sumathi, 2012; Brovida and Rothuizen, 2010; Prins *et al.*, 2010; Tantary *et al.*, 2014; Elhiblu *et al.*, 2015; Jeena, 2019 and Prebavathy *et al.*, 2020) [39, 4, 31, 43, 11, 16, 30]. The liver is responsible for homeostasis as it is the site for synthesis, clearance or both of most procoagulants, anticoagulants and regulators of fibrinolysis. Patients with liver disorder witness decreased synthesis of procoagulant factors and tend to balance it by losing anticoagulants. The decrease in platelets could be a reflection of this homeostasis (Kelley *et al.*, 2015) [17].

The elevated levels of TLC could be explained as representation of the ongoing inflammatory process in the ailing hepatobiliary system (Brempelis and Crispe, 2016; Lecoindre and Arpaillange, 2010; Lathamani and Nalinikumari, 2015; Elhiblu *et al.*, 2015; Bhatti, 2020 and Prebavathy, 2020) [4, 21, 20, 11, 2, 30].

Monocyte levels increase in hepato biliary disorders (Chohan *et al.*, 2009) [8] and (Tantary *et al.*, 2014) [43]. In a healthy liver, neutrophils, monocytes, liver dendritic cells and lymphocytes constantly navigate through the liver in the bloodstream. They do so to set them up for extravasation into the liver upon detection of inflammatory signals. Upon liver injury, innate myeloid cells-including neutrophils and monocytes-are rapidly recruited to the site of injury to perform phagocytosis, antiviral immunity, antigen presentation, immune suppression and tissue repair. Their population increases upon detection of such situation (Brempelis and Crispe, 2016) [3].

In hepatic insufficiency, neutrophil levels increase in the affected animal comared to healthy animal (Voros *et al.*, 1991; Vijayakumar *et al.*, 2008; Washabau, 2010; Saravanan

et al., 2014; Elhiblu *et al.*, 2015; Ranjithkumar *et al.*, 2017; Jeena, 2019; Tiwari *et al.*, 2001; Ettinger and Feldman, 2005; Thusara *et al.*, 2006; Chohan, *et al.*, 2007; Prebavathy, 2020 and Lakshmi *et al.*, 2018) [52, 51, 53, 33, 11, 32, 16, 47, 12, 46, 7, 30, 19]. The increase in the neutrophil count in liver diseases can be explained as a way adopted by the liver to cope with the disease. The neutrophils help by functioning as anti-infection, immune regulators, with anti-tumor properties and helps in tissue repair. Neutrophils, however, may also act as negative impact agents by causing tissue injury, immune paralysis and promotion of tumor metastasis under the specific tumor microenvironment. In different stages of liver disorders, neutrophils act and react in different ways, functioning as protective or destructive (Liu *et al.*, 2021) [22].

4. Conclusion

Anaemia is a persistent feature in hepatobiliary disorders which is reflected in the haematological profile of the affected dogs including haemoglobin (g/dL), RBC (mil/mm3), MCH (fl), HCT (%), MCV (fl), MCHC (g/dL), lymphocyte (%), plateletes (103/µL), TLC (103/mm^3), neutrophil (%) and monocyte (%).

5. References

1. Belza C, Thompson R, Somers GR, deSilva N, Fitzgerald K, Steinberg K, *et al*. Persistence of hepatic fibrosis in paediatric intestinal failure patients treated with intravenous fish oil lipid emulsion. Journal of Paediatric Suregry. 2017;52:795-801.
2. Bhatti AK. Investigations on ascites. M.V.Sc thesis (Veterinary Medicine), Chaudhury Sarwan Kumar Himachal Pradesh Krishi Vishvavidyalaya, Palampur; c2020.
3. Brempelis KJ, Crispe IN. Infiltrating monocytes in liver injury and repair. Clinical & Translational Immunology. 2016;5(11):e113.
4. Brovida S, Rothuizen J. Liver and Pancreatic diseases. In: Ettinger, S. J. and Feldman, E. C. (Eds.). Textbook of Veterinary Internal Medicine. 7th Edition. Elsevier Saunders Co., St. Louis; c2010. p. 1609-1690.
5. Burrows CF, Taboada J. Liver disorders 9. Clinical Medicine Dog Cat. 2009;1:397.
6. Chaturvedi M, Gonaie AH, Shekawat MS, Chaudhary D, Jakhar A, Chaudhari M. Serum haemato-biochemical profile in ascitic dogs. Haryana Veterinarian. 2013;52:129-130.
7. Chohan AS, Bansal BK, Randhaw CS, Dhaliwal PS. Liver dysfunctions in dogs. Indian Veterinary Journal. 2007;84(10):1042-1044.
8. Chohan AS, Bansal BK, Dhaliwal PS, Ranjan R. Haematobiochemical changes in dogs suffering from hepatobiliary diseases. Indian Journal of Veterinary Medicine. 2009;29:73-76.
9. Dawidowski J, Pietrzak A. Rare causes of anemia in liver diseases. Advances in Clinical and experimental Medicine: Official Organ Wroclaw Medical University. Mar; c2022. p. 567-574.
10. Dial SM. Clinicopathological Evaluation of the Liver. Veterinary Clinics of North America Small Animal Practice. 1995;25(2):257-273.
11. Elhiblu MA, Dua K, Mohindroo J, Mahajan SK, Sood NK, Dhaliwal PS. Clinic-haemato-biochemical profile of dogs with liver cirrhosis. Veterinary World. 2015;8(4):487-491.
12. Ettinger SJ, Feldman EC. Liver and pancreatic diseases. In: Textbook of Veterinary Internal Medicine, 6th Edn. Elsevier Saunders Co., St. Louis. c2005. p. 1421-1495.
13. Gogulski M, Cieślak A, Grabska J, Ardois M, Pomorska-Mól M, Kołodziejski PA, *et al*. Effects of silybin supplementation on nutrient digestibility, hematological parameters, liver function indices, and liver-specific mi-RNA concentration in dogs. BMC Veterinary Research. 2021;17(1):1-14.
14. Gonzalez-Casas R, Jones EA, Moreno-Otero R. Spectrum of anemia associated with chronic liver disease. World Journal of Gastroenterology. 2009;15(37):4653-4658.
15. Jain NC. Schalm's Veterinary Haematology. (Lea and Febiger. Philadelphia, USA.) c1986.
16. Jeena A. Diagnosis and clinic-therapeutic studies on canine hepatic dysfunction. M.V.Sc. thesis (Veterinary Medicine), G.B. Pant University of Agricultural & Technology, Pantnagar; c2019.
17. Kelley D, Lester C, Shaw S, deLaforcade A, Webster CRL. Thromboelastographic Evaluation of Dogs with Acute liver Disease. Journal of Veterinary Internal Medicine. 2015;29:1053-1062.
18. Kumar M, Mondal DB, Saravanan M, Sharma K. Therapeutic management of hepatobiliary dysfunction in canines. Intas Polivet. 2013;14(1):117-121.
19. Lakshmi K, Padmaja K, Nagaraj P, Gopala Reddy A. anad Gnana Prakash, M. Haemato-Biochemical studies of hepatobiliary disorders in dogs. International Journal Current Microbiology Applied Sciences. 2018;7(01):1406-1411.
20. Lathamani VS, Nalinikumari K. Studies on therapeutic efficacy of Liv 52 in dogs suffering from hepatic disorders. International Journal of Innovation Research Science English Technology. 2015;4(8):7361-7365.
21. Lecoindre P, Arpaillange C. Jaundice in the dog. Veterinary Focus. 2010;20(3):17-24.
22. Liu K, Wang F, Xu R. Neutrophils in liver diseases: pathogenesis and therapeutic targets. Cellular and Molecular Immunology. 2021;18:38-44.
23. Morse EE. Mechanisms of hemolysis in liver disease. Annals of Clinical and Laboratory Science. 1990;20(3):169-174.
24. Panchal R, Rao N, Raval S, Sadhu D, Bharai M. Epidemiological Studies on Anaemia in Dogs in Anand, Gujarat. The Indian Journal of Veterinary Sciences and Biotechnology. 2022;18(02):76-80.
25. Parker MD. An unusual cause of abdominal distension in dog. Veterinary Medicine; c2002. p. 189-195.
26. Patnaik AK, Hurvitz AI, Leiberman PH. Canine hepatic neoplasms: A clinicopatholgical study. Veterinary Pathology. 1980;19:553-564.
27. Popova I, Shabunin S, Vatnikov Y, Yagnikov S, Karamyan A, Babichev N, *et al*. Integral Intoxication Indices in Liver Diseases in Dogs: Clinical Characteristics and Relevance. Liver. 2020;4:5.
28. Pradeep K, Yathiraj S, Ramesh PT, Leena G, Narayanswamy HD. Clinico-Haemato-Biochemical and Ultrasonographic alterations in dogs with non infectious hepatic disorders associated with hypo-albuminemia. International Journal of Advanced Biotechnology and Research. 2017;7(3):585-589.
29. Pradhan MS, Dakshinkar NP, Waghaye UG, Bodhke AM. Successful treatment of ascites of hepatic origin in dog. Veterinary World. 2008;1(1):23.

30. Prebavathy T, Amaravathi P, Rajesh K, Vaikuntarao V, Bharathi, S. and Raghunath, M. Haematobiochemical alterations in hepatic diseases in dogs. Journal of Entomology and Zoology Studies. 2020;8(5):1382-1384.
31. Prins M, Schellens CJMM, van Leeuwen MW, Rothuizen J, Teske E. Coagulation disorders in dogs with hepatic disease. Veterinary Journal. 2010;185(2):163-68.
32. Ranjithkumar M, Srinivasan SR, Balachandran C. Chronic hepatitis in dogs: finding incidence, haematological and peritoneal fluid changes in histologically confirmed cases. International Journal of Science, Environment and Technology. 2017;6(1):580-590.
33. Saravanan M, Mondal DB, Sarma K, Mahendran K, Vijayakumar H, Sasikala V. Comprehensive study of haematobiochemical, ascetic fluid analysis and ultrasonography in the diagnosis of ascites due to hepatobiliary disorders in dog. Indian Journal of Animal Sciences. 2014;84(5):503-506.
34. Sarma K, Das G, Konwar B, Bayan H, Ali A. Haemato-biochemical Profile of canine ascites. Indian Journal of Veterinary Medicine. 2009;29(2):121-122.
35. Sharma MC, Pathak NN, Lal SB. Liver- Structure, Disorders, Diagnosis and Therapeutic Management. IVRI Publication; 2001.
36. Shrivastava S, Gupta N, Gupta DK, Shukla PC. Haematological and enzymatic alterations associated with hepatic disorders in canines. Intas Polivet, 2010, 11(2).
37. Smirnova IP, Kuznetsova OM, Shek D, Ivanova-Radkevich VI, Sachivkina NP, Gushchina YS. Investigation of the immunogenic properties of anti tumor enzyme l-lysine-alpha-oxidase. FEBS Journal. 2018;8(S1):234.
38. Snedecor GW, Cochran WG. In: Statistical Methods Viii Edn. (Oxford and IBH Publishing Company, New Delhi); c1994.
39. Sumathi D. Study on the comparative efficacy of diagnostic tests in the early diagnosis of canine liver diseases. Ph.D. thesis (Clinical medicine and Therpeutics). Tamil Nadu Veterinary and Animal Sciences University; c2012.
40. Sumathi D, Prathaban S, Selvaraj P, Dhanapalan P, Murali B, Manohar, *et al*. 2D and 3D ultrasonographic study of hepatobiliary disorders in dogs and their etiological pattern. Indian Journal of Veterinary Medicine. 2017;37(1):1-8.
41. Taboada J. Liver disorders. In Clinical Medicine of the Dog and Cat. CRC Press; 2016. p. 351-378.
42. Tandel F, Jani R, Bilwal A, Vasava P. Etiopathology and Haematobiochemical Alteration in the Anaemic Dogs of in and Around Anand Region, Gujarat. Journal of Animal Research. 2019;9(6):935-943.
43. Tantary HA, Soodan JS, Chrirag S, Ansari MM, Kumar S, Imtiyaz T. Diagnostic studies in dogs with hepatic disorders. International Journal of Veterinary Science. 2014;3(4):210-215.
44. Telagar VN. Studies on Clinicopathological and Ultrasonographic Evaluation of Hepatic Disorders in Dogs. Ph.D. Thesis. Veterinary Medicine. Karnataka, Veterinary, Animal and Fisheries Sciences University, Bidar; c2017.
45. Thomas HC, Freni M, Sanchez-Tapias J, de Villiers D, Jain S, Sherlock S. Peripheral blood lymphocyte populations in chronic liver disease. Clinical and Experimental Immunology. 1976;26(2):222-227.
46. Thusara MR, Smitha JP, Ajithkumar S, Vijaykumar K, Baby PG. Hepatic cirrhosis associated ascites in a dog. The Indian Veterinary Journal. 2006;83:655-656.
47. Tiwari P, Varshney JP, Hoque M. Biliary obstruction in dogs: diagnosis and treatment. Indian Journal of Veterinary Medicine. 2001;21(2):115-116.
48. Tripathi R. Studies on ultrasonographic diagnosis of hepatic and renal disorders of dogs. M.V.Sc. thesis (Veterinary Medicine), Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur; 2008.
49. Vatnikov YuA, Kulikov EV, Kubatbekov TS, Kuznetsov VI, Sturov NV, Shirmanov VI. Diagnosis of violations of microcalculation in the late recovery period after thrombosis of cerebral vessels. Prensa Medica Argentina. 2019;105(1):1000335.
50. Vijayakumar G, Subramanian M, Thirunavukkarasu PS. Treatment of canine hepatic disorder with silymarin. Indian Veterinary Journal. 2004;81:930-932.
51. Vijayakumar G, Pandiyan V, Balasubramanian M. Haematobiochemical changes in dogs with hepatic disorders. Indian Veterinary Journal. 2008;85(30):341-342.
52. Voros K, Wlada RS, Marsi A, Vrabely T, Fenyves B, Nemeth T. Ultrasonographic study of feline lower urinary tract diseases: 32 cases. Acta Veterinaria Hungarica. 1991;45(4):387-395.
53. Washabau R. Laboratory tests for liver disease. Vet. Focus. 2010;20(3):32-37.
54. Watson FJ, Bunch SE. Diagnostic tests for the hepatobiliary system. In: Small Animal Internal Medicine 4 Edn. St. Louis, Missouri: Elsevier Mosby; 2009. p. 496-519.
55. Watson P. Canine Breed-Specific Hepatopathies. Veterinary Clinical North American Small Animal Practice. 2017;47(3):665-682.
56. Xie X, Wang L, Yao M, Wen X, Chen X, You H, *et al*. Correlation between red blood cell count and liver function status. Chinese Journal of Hepatology. 2016;24(2):119-122.
57. Yang J, Yan B, Yang L, Li H, Fan Y, Zhu F, *et al*. Macrocytic anemia is associated with the severity of liver impairment in patients with hepatitis B virus-related decompensated cirrhosis: a retrospective cross-sectional study. BMC gastroenterology. 2018;18(1):161.