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ORIGINAL ARTICLE

A Survey Parameters of Hepatic Vessels in Healthy Cats by Color Doppler Ultrasonography

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Keywords:

Cat;

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Abstract

Objective- This survey was accomplished to describe the hepatic artery and portal vein indices in healthy domestic cats by color Doppler ultrasonography technique.
Design- Retrospective experimental study.
Animals- Twenty domestic short hair (DSH) cats (10 males and 10 females).
Procedures- Doppler indices of liver vascular (portal vein and hepatic artery) such as PSV, EDV, RI, PI, MV, VF and the spectral wave forms were measured in the studied cat's population (two equal groups of ten each) .
Results- The mean and deviation of portal vein were as follow: PSV: 40.68 ± 9.82, EDV: 23.38 ± 5.78, RI: 0.48 ± 0.10, PI: 0.72 ± 0.26, MV: 2.49 ± 0.64, VF: 25.81 ± 5.04 and for hepatic artery were included PSV: 49.79 ± 9.45, EDV: 31.92 ± 5.05, RI: 0.59 ± 0.09, PI: 0.85 ± 0.20, VF: 34.73 ± 5.47 and MV: 3.03 ± 0.44 respectively.
Conclusion and clinical relevance- The obtained results showed that there was not a significant difference between males and females for indices of liver vascular (p>0.05). These data can be used for comparison with the various hepatic diseases in cats. It should be noted that the importance of hepatic blood flow is more in cats than dogs, due to defect in liver enzymes.

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1. Introduction

A few years ago was known production technology and characteristics of ultrasound waves. Although the principles of physical phenomena are unchanged, but the correct understanding of ultrasound, is more important than ever. Doppler ultrasonography of the liver is primarily used to evaluate flow velocity, flow direction, and spectral patterns associated with the hepatic and portal veins. The ultrasound machine's software automatically computes the mean flow velocity within the vein. Ideally, incident angles of less than 60 degrees should be used to obtain reliable measurements.[1]

Doppler ultrasound has been used in medicine for many years. Effective use of this work is the first and still most common, is testing fetal heart rate during different stages of pregnancy. Color Doppler ultrasound is used as a convenient method to study the vascular anatomy. This method is non-invasive and without side effects, so can be considered a good alternative to angiography.[1,2] This method gives us very good information on hemodynamics. Considering that the survey of hepatic artery Doppler ultrasonography are valuable in the diagnosis of many diseases including hepatic artery shunts, cirrhosis of the liver, hepatomegaly, bleeding, congenital liver diseases, tumors and disorders of the liver parenchyma.[2] Due to the changes in blood flow in the liver can be considered as an early sign of serious liver failure, so knowledge the Doppler indices of liver (portal vein and hepatic artery), such as maximum systolic blood flow (PSV), end-diastolic blood flow velocity (EDV), vascular resistance index (RI), pulse index plasticity (PI), Mean blood velocity (MV), velocity factor (VF) and spectral wave forms, are valuable and important indicator for the health of the liver.[3]

In ultrasonic Doppler devices, waves are emitted into a blood vessel through an ultrasonic transducer and the radiation scattered from the mobile red blood cells is detected by the same transducer or another. As regards to the measured values of blood flow velocity, it can be useful as a means of detecting vascular complications. The Doppler spectral patterns of the hepatic veins are complex and depend on changes in cardiac activity, respiration, and intra-abdominal pressure. Therefore, the hepatic vein waveforms should be obtained at normal end- expiration in a quiet animal whenever possible. The normal hepatic venous pulsed Doppler waveform demonstrates marked variation in the direction and velocity of flow because of right atrial activity. The portal vein is visualized by either a ventral or right intercostal approach, whereby it can be seen entering the liver at the portal hepatis.[1]

The characteristic tetraphasic waveform of a normal hepatic vein is similar in human and dog. In human, analysis of the waveform has been shown to be useful in the differential diagnosis of right-sided heart diseases and various liver diseases.[4]

Most companion cats in Iran are domestic short hair (DSH), so the results of recent research can be helpful in the diagnosis of liver different diseases in cats. It should be noted that the importance of hepatic blood flow is more in cats than dogs, due to defects in liver enzymes (glucuronyl transferase).[5] A few studies are found in dogs and cats about the liver vascular indices,[6,7] so the aim of the present survey was to evaluate the hepatic artery and portal vein in a population of clinically healthy cats in Ahvaz district.

2. Materials and Methods

In the present study, twenty cats (10 males and 10 females) were selected of domestic short hair (DSH) breed with age 1-2 years old (average = 18 months). Weight range of the cats was 2.5 to 3 kg (mean = 2.7 kg). Characteristics of each cats were recorded in the information registration form. The animals were kept in Veterinary Hospital and clinical examinations were performed to confirm their health (vaccination and administration of anti-parasitic drugs); then the necessary tests were done inclusive of Doppler ultrasound and measurement of biochemical profiles. For this purpose, at least two ml of blood were

taken from each cat, and after serum isolation, liver enzymes were measured inclusive of alanine aminotransferases (ALT), aspartate aminotransferase (AST) and alkaline phosphatase (ALP).

After confirming the health of the cats, the right abdominal region was shaved. The skin of the area was washed well with water and soap and cleansed with alcohol. In the next step, the Doppler ultrasound was performed. For ease of work, diazepam was injected to cats intravenously with dosage of 0.5 mg/kg body weight. The cats were sleeping on the left side, then the abdominal region was prepared with sufficient amount of ultrasonography gel. First ultrasonography (Medisone 8000 live, South Korea) was done for confirmation of healthy in cats with a transducer of 8 MHz, and then Doppler ultrasonography was performed from the vessels. Select the sample size and the desired vessel angle was set to under 60°.[1] Then two methods were measured. Manual method: After drawing the curvature of the corresponding vessel, the area was drawn below the curve manually for determination of indices. Automatic method: The devices of vascular parameters were shown automatically.

In the following, the length section of the vessel was determined in each of the samples, and then the cross section of the vein was achieved by rotating the 90 degrees of transducer. All the measurements were made from hepatic artery and portal vein. The studied vascular parameters were included the maximum flow rate of the blood in systole (PSV), blood flow velocity at the end of diastole (EDV), average blood flow rate (MV), artery resistance index (RI), pulse Index (PI), blood volume (VF) and shape of spectral waves. The velocity of vascular parameters was recorded according to Cm/sec. The results were analyzed using t-test for two dependent and independent samples. The values were considered significant less than 0.05.

3. Results

In the present study, the indices of portal vein and hepatic artery were calculated by color Doppler ultrasonography technique. The mean and standard deviation of portal veins were as follow: PSV: 40.68 ± 9.82, EDV: 23.38 ± 5.78, RI: 0.48 ± 0.10, PI: 0.72 ± 0.26, MV: 2.49 ± 0.64, VF: 25.81 ± 5.04 and for hepatic arteries were included PSV: 49.79 ± 9.45, EDV: 31.92 ± 5.05, RI: 0.59 ± 0.09, PI: 0.85 ± 0.20, VF: 34.73 ± 5.47 and MV: 3.03 ± 0.44 respectively. There was not a significant difference between portal vein indices in male and female cats (p>0.05) (Table 1), as well as, there was not a significant relationship between hepatic artery indices in male and

Table 1. Mean and standard deviation of portal vein in male and female cats.

Indicator	**PSV**	**EDV**	**RI**	**PI**	**MV**	**VF**
Gender	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**
Female	40.51 ± 7.60	24.06 ± 6.45	0.51 ± 0.10	0.80 ± 0.22	2.52 ± 0.67	24.4 ± 5.11
Male	40.85 ± 12,07	22.69 ± 5.29	0.46 ± 0.10	0.64 ± 0.28	2.46 ± 0.65	27.22 ± 4.80
Total	40.68 ± 9.82	23.38 ± 5.75	0.48 ± 0.10	0.72 ± 0.26	2.49 ± 0.64	25.81 ± 5.04

Table 2. Mean and standard deviation of hepatic artery in male and female cats.

Indicator	**PSV**	**EDV**	**RI**	**PI**	**MV**	**VF**
Gender	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**
Female	50.41 ± 8.64	33.02 ± 4.52	0.60 ± 0.11	0.80 ± 0.24	2.97 ± 0.40	32.9 ± 4.16
Male	49.17 ± 10.62	30.82 ± 5.54	0.57 ± 0.07	0.90 ± 0.14	3.08 ± 0.44	36.57 ± 6.20
Total	49.79 ± 9.45	31.92 ± 5.05	0.59 ± 0.09	0.85 ± 0.20	3.03 ± 0.44	34.73 ± 5.47

female cats (p>0.05) (Table 2). The obtained results from the examination of the hepatic artery and vein are as follows in the male and female cats.

Longitudinal and transverse scans of the portal vein and hepatic artery in male cats are presented in Figures 1- 4. Also, the longitudinal and transverse scan obtained from the portal vein and the hepatic artery in females are shown in Figures 5-8. It should be noted that all serum samples, except for 2 cases, had liver enzymes (ALP, ALT and AST) within the normal range. Two another cat were replaced instead of the two cases that were excluded from the research.

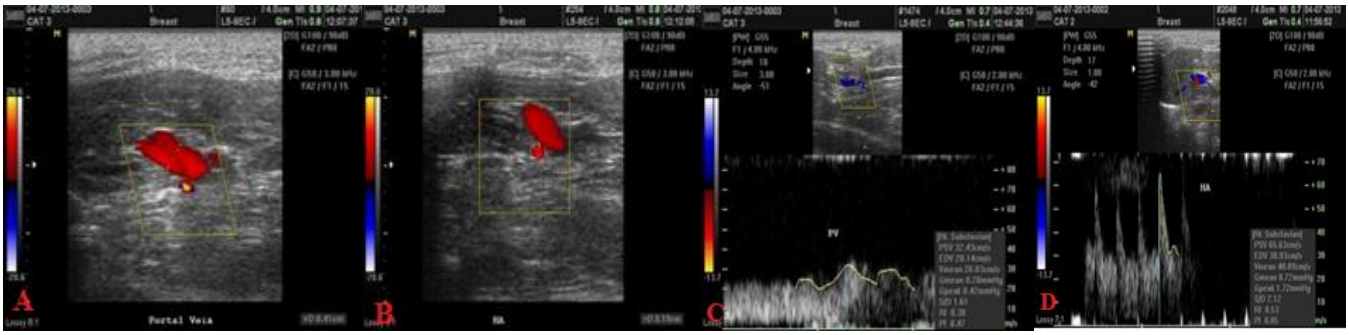

Figure 1. A- Longitudinal section of the portal vein of liver (red) in a male cat, B- Transverse section of the hepatic artery in a male cat, C- Spectral wave of the liver vein in a male cat, D- Spectral wave of the hepatic artery in a male cat.

Figure 2. E- Cross section of the hepatic artery in a female cat, F- Cross section of the portal vein of liver in a female cat, G- Spectral wave of the liver portal vein in a female cat, H- Spectral wave of the hepatic artery in a female cat.

4. Discussion

Color Doppler ultrasonography is used to measure blood flow non-invasively. In fact, the Doppler technique provides a unique feature for ultrasound to determine the function of the organs. It should be noted that it is very important and valuable to detect normal parameters of blood flow velocity in different vessels for the diagnosis of diseases.[1] Usually, pulse wave Doppler ultrasonographic examinations are easily interrupted by respiratory motion; therefore, identification and evaluation of the hepatic vein waveform are difficult when dogs or cats are exhibiting severe panting or an unstable status.[8] In the present survey, we tried to determine the rate of blood flow and their related indices in the studied cats and measure the normal parameters. The indicators were compared in each group between themselves also. The values of PSV, EDV, PI, and RI are the parameters that are commonly used in Doppler ultrasonography to detect arterial diseases in human and animal. Particularly, the PSV value has been identified as one of the most reliable parameters in Doppler ultrasonography for the diagnosis of stenosis in the human body.[7,9] Wang *et al*. (2014) measured the diameter of the liver veins and arteries, maximal blood flow in the vein, PSV, and RI of the liver arteries in twenty eight Rosa monkey (16 males and 12 females). The maximum blood flow rate was 40.2 ± 13.7 Cm/sec in the portal vein. The PSV and RI indices of liver arteries were 72.2 ± 25.4 and 0.67 ± 0.10 respectively.[10] In the present study that was done on twenty healthy cats (10 males and 10 females), the PSV and RI parameters of liver arteries were 49.79 ± 9.45 and 0.59 ± 0.09 Cm/sec Respectively. Eveno *et al.* (2012),

investigated the association between the VF of the liver and mesenteric arteries in two groups of rats by Doppler ultrasound. The first group was mice whose angiogenesis was induced due to liver metastases with low tumor masses, and the second group, liver transplantation, was stimulated due to the removal of fifty percent of the liver tissue. The results were that in metastatic mice, VF of liver arteries decreased without altering in the mesenteric artery, and in the mice that tumor masses had been removed from the liver, both VF indices of liver and mesenteric arteries increased.[11] In the present study, the VF indices of portal vein and hepatic artery were 25.81 and 34.73 in cats respectively. All parameters were located in normal range.

In an experimental study, with the help of Bonnin *et al*. (2007), PSV, EDV, and liver arterial blood flow velocity indices were measured in twelve mice with hepatocellular carcinoma. The PSV value of the liver arteries was 1.5 times, the value of EDV was 1.6, and the blood flow rate was two times higher than that of the liver arteries in the control group. According to the above results, it is possible that if these indices increase with this ratio, liver cancer can be suspected.[9] In the present study, the PSV, EDV and MV parameters of liver arteries were 49.79 ± 9.45, 31.92 ± 5.05, and 3.03 ± 0.44 Cm/sec respectively. Doppler normal vascular indicators can help to the diagnosis of liver diseases.

Lamb *et al*. (1999) conducted on ten healthy Beagle dogs, twenty puppies and seven dogs with congenital or acquired liver impairment. They reported that the PSV and RI values were lower in puppies than adults, two dogs with congenital arthritis-fistulas had a higher PSV and RI than normal puppies, and also the difference was significant between adult dogs and three dogs with thrombosis and two dogs with acquired liver dysfunction. They stated that there was differences in age and breed of the studied dogs.[12] In the present research, all cats were of DSH breed and in a similar age range. There was not a significant difference between the PSV and RI values in male and female cats.

Scheinfeld *et al*. (2009) showed that accurate interpretation of the hepatic vein waveform detected with pulsed-wave Doppler ultrasonography is clinically valuable, as it is greatly influenced by both cardiac and hepatic factors. Congenital or acquired vascular disorders affect the values of Doppler vascular markers in the liver system with blood diversion of vein and as a result of reduction of blood supply to the liver.[1] In another study by Schneider *et al*. (1999), PI index of liver arteries and velocity of venous blood flow were measured in patients with cirrhosis and concluded that PI in comparison to the control group showed a significant increase, so that PI index was 1.14 ± 0.18 in the patient human and in contrast, PI was 0.92 ± 0.1 in the control group and in parallel, the liver blood flow rate increased.[3] In the present study, RI index of hepatic artery was 0.59 ± 0.09 and for PI was 0.85 ± 0.20. It can be predicted that if the values of these indices increase, we can be suspected to liver different diseases. In chronic liver disorders, other organs may also be affected by adaptive mechanisms.

To evaluate whether retrobulbar circulation is affected in liver diseases, Sorrentino *et al*. (2004) performed a study on patients (human) with liver chronic diseases and cirrhosis using color Doppler ultrasonography. They concluded that in high blood pressure in the vein, the RI index was more affected than other indices and the RI of the central retinal artery was higher in patients than the control group.[13] Examining the retrobulbar circulation in the eye provides an opportunity to evaluate the end-stage circulation of the arterial branches.[1]

In another study by Ferrandis *et al*. (2013) on seventy five dogs with liver-spleen diseases, it was found that the PI index of arterial spleen was higher in patients than normal, suggesting that measuring the PI value of the spleen artery is beneficial in the prediction of liver-spleen diseasess.[14] In an experimental study, by Novellas *et al*. (2008) on twenty dogs with liver diseases, the mean RI, PI kidney, and systolic blood pressure were significant compared with the healthy group.[8] Doppler indicators of the liver are not

affected only by liver diseases, and liver disorders can also affect the values of other organs. In a study by Baere *et al*. (1998) on twenty five pigs, the embryo-induced embolism was investigated in order to prolong the time of contact between drug and tumor tissue. In their research, RI index for hepatic artery was increased one hour after the injection of pure iodized oil, as well as water-oil emulsion.[15] In our study, RI parameters for hepatic artery and portal vein were 0.59 and 0.48 respectively. Mitchell *et al*. (1999) evaluated the effects of acute changes in renal vascular resistance and blood pressure on vascular resistance index by Doppler ultrasound. They concluded that the RI index is not affected by acute renal vascular changes.[16]

Since the level of liver glucuronyl transferase is low in the cats and some drugs have a higher sensitivity in cats, as well as, changes in liver blood flow can have a direct influence on the metabolism of drugs, thus the evaluation of liver blood flow in cat is more preferable than dog. Petersen *et al*. (2011) aimed to determine the level of peripheral blood flow in the rainbow trout. In their research, the VF and the volume of impaired lung vein were compared to the nutrient-deprived group and the saturated nutrient group. The results of their studies were reduction in the volume of impaction and VF of the liver in the deprived group of foods. The value of this indicator is important in the state of deprivation of food and is likely to be less than this amount.[5]

An another experimental study by Yarmenitis *et al*. (2000) was carried out on thirty Wistar male rats implanted subcutaneously with the tumor genes of Walker 256.[17] The results showed that a small group the cells emerged from the tissue without the formation of the vascular phase on the fourth day. In their research, the VF and PI of the liver arteries were higher than the control group and the VF of the vein decreased. Their results showed that the measurements of these indices were helpful in the early stages of liver metastases by color Doppler ultrasonography, which is still a vascular phase and it is not formed for cancer diagnosis.[17] In the present study, the PSV levels of the portal vein and hepatic artery were 40.68 ± 9.82 and 49.79 ± 9.45 Cm/sec. The EDV of the vein and hepatic artery were 23.38 ± 5.78 and 31.92 ± 5.05 Cm/sec respectively. The RI levels of the portal vein and hepatic artery were 0.48 ± 0.10 and 0.59 ± 0.09 Cm/sec respectively. The other measured indices in the present research (PI, VF and MV) did not differ significantly between two gender (male and female). Considering the available sources for the indexes, it should be noted that for the interpretation of the obtained values from Doppler ultrasonography, it is necessary to determine the normal values in the first stage. There is no fixed and specific values for most animals, even if there is values mentioned, so it is recommended that each Doppler ultrasound source is essential to make its own standard and interpretation. With regard to the above subjects, and considering that the DSH cats had not been studied for the liver vascular indices, the obtained values can be considered as normal indices in comparison to liver different diseases.

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Conflict of Interests

The authors declare that they have no conflict of interest.

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چکیده

بررسی پارامترهای عروق کبدی در گربه‌های سالم به روش اولتراسونوگرافی داپلر رنگی

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هدف- هدف از انجام مطالعه حاضر، توصیف شاخص‌های سرخرگ کبدی و ورید باب در گربه‌های اهلی سالم با تکنیک اولتراسونوگرافی داپلر رنگی بود.

طرح- مطالعه تجربی گذشته‌نگر

حیوانات- ۲۰ قلاده گربه اهلی (۱۰ قلاده نر و ۱۰ قلاده ماده)

روش کار- شاخص‌های داپلر عروق کبدی (ورید باب و سرخرگ کبدی) از قبیل حداکثر سرعت جریان خون در سیستول (PSV)، سرعت جریان خون در انتهای دیاستول (EDV)، شاخص مقاومت عروقی (RI)، شاخص ضربان (PI)، متوسط جریان خون (MV)، حجم خون (VF) و شکل امواج اسپکترال آن‌ها، در جمعیت گربه‌های مورد مطالعه (۲ گروه مساوی ۱۰ تایی)، اندازه‌گیری شدند.

نتایج- میانگین و انحراف معیار به ترتیب برای سیاهرگ باب PSV: ۴۰/۶۸±۹/۸۲؛ EDV: ۲۳/۳۸±۵/۷۸؛ RI: ۰/۴۸±۰/۱۰؛ PI: ۰/۷۲±۰/۲۶؛ MV: ۲۵/۸۱±۵/۰۴؛ VF: ۲/۴۹±۰/۶۴ و برای سرخرگ کبد، PSV: ۴۹/۷۹ ±۹/۴۵؛ EDV: ۳۱/۹۲±۵/۰۵؛ RI: ۰/۵۹±۰/۰۹؛ PI: ۰/۸۵±۰/۲۰، VF: ۳۴/۷۳±۵/۴۷ و MV: ۳/۰۳±۰/۴۴ بودند.

نتیجه‌گیری و کاربرد بالینی- نتایج بدست آمده نشان داد که از نظر شاخص‌های عروق کبدی، بین گربه‌های نر و ماده اختلاف معناداری وجود نداشت ($p>0/05$). این اطلاعات، می‌تواند برای مقایسه با بیماری‌های مختلف کبدی در گربه‌ها بکار برده شود. لازم به ذکر است که اهمیت جریان خون کبدی در گربه‌ها نسبت به سگ‌ها، به دلیل نقص در آنزیم‌های کبدی، بیش‌تر است.

واژه‌های کلیدی- گربه، داپلر، کبد، اولتراسونوگرافی، عروق.