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EVALUATION OF RENAL VASCULAR RESISTANCE AND BLOOD PRESSURE IN DOGS WITH DIFFERENT RENAL DISEASES

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Abstract

The kidney is a well-vascularised organ and suitable to be evaluated by Doppler ultrasound, which is a non-invasive technique that can be used to estimate the renal vascular resistance by calculation the resistive index (RI) and pulsatility index (PI). RI and PI can be calculated from renal arteries, interlobular arteries, and arcuate arteries. In human patients, renal vascular resistance has been reported to be associated with the early hypertensive renal damage and also to correlate with the systemic blood pressure.
The study was conducted over a two year period (December 2012- December 2014) in the Department of Internal Medicine of the Faculty of Veterinary Medicine Bucharest, on twenty eight dogs with different renal diseases. Significant differences were found between renal vascular resistance and red blood cell count, creatinine and blood urea nitrogen. Increased intrarenal vascular resistance may be associated with hypertension as a result of renal disease.
The aim of this study was to assess renal vascular resistance in dogs with renal disease and the relation between renal RI and PI with systolic blood pressure in dogs with different renal diseases.

Key words*:dog, kidney, pulsatility index, resistive index.*

INTRODUCTION

In dogs with normal renal function arteries have low resistance to blood flow, seen as high continuous diastolic flow, which decreases during diastole. The vascular aspect of renal blood flow can be evaluated and can also provide information about vascular resistance using calculations such as resistive index (R.I.) and pulsatility index (P.I.) through the use of Doppler ultrasound technique. Duplex Doppler evaluation by measuring the R.I. and P.I. may be useful for guiding renal diseases in cases where the gray scale of simple sonography of the kidney cannot conclude modifications, or when the only anomaly observed is a relatively increased renal cortex (Rivers et al., 1997; Novellas et al., 2007; Chang et al., 2010).

Systemic hypertension is common in dogs with different renal diseases due to the fact that the kidney is injured by hypertension and also participates in the development and persistance of it (Bartges et al., 1996; Brown et al., 1998).

Renal failure and hypertension in dogs may determine more likely development of uremic crises and reduced renal function. (Jacob et al., 2003; Tublin et al., 2003).

When hypertension has settled in, it will accelerate the destructive processes of nephrons (Szatmari et al., 2001).

MATERIALS AND METHODS

Fifty unsedated dogs were examined at the Department of Internal Medicine of the Veterinary Medicine Faculty of Bucharest.

All cases were subjected to an examination protocol consisting of physical examination, paraclinical tests to evaluate the renal function (biochemical profile, urinalysis) and abdominal ultrasonography in order to evaluate the renal structure.

After performing this tests, the cases were classified in two groups. Group 1 included 22 cases with normal findings, clinically healthy dogs, while Group 2 included 28 cases with various renal diseases. Group 1 and Group 2 included dogs of different genders and breeds. Both groups was examinated ultrasonographic with the same ultrasound machine, technique and operator to avoid variations in results.

Systolic blood pressure was determined after 10-15 minutes of environmental adjustment for every case taken in study, using PetMAP, a blood pressure measurement device, the cuff was placed in all cases on the coccidian artery.

Triplex Doppler ultrasonography was performed with the ESAOTE MyLab 30 Gold VET ultrasound machine. The hair was clipped and acoustic gel was applied to the skin. The dogs were placed in lateral recumbency, right and then left recumbency, to scan the kidneys sequentially.

We used a sectorial multifrequency transducer with different frequences, from 5, 6,6 to 8 MHz, depending on the dog size; and color Doppler to examine the intrarenal vascularization.

Interlobular and arcuate arteries were examined using the frequency of 5 MHz at the width of 1 - 2 mm obtaining a subsequent pulse Doppler interrogation. A total of 8 to 12 Doppler waveforms were used to determine the mean R.I. and P.I. for each kidney, in two separate locations of the renal parenchyma. The ultrasound device automatically calculates the R.I. and P.I., after manually delimitation of peak systolic and diastolic velocity and time average of maximum velocity.

R.I. = (peak systolic velocity - end diastolic velocity)/(peak systolic velocity).

PI = (peak systolic velocity - end diastolic velocity)/(time average maximum velocity).

The values of R.I., P.I. and systolic blood pressure of the Group 2 were compared with the values of the Group 1 using TTest function of Microsoft Excel program. Statistical significance was settled ($P< 0.05$) and results were given as mean ± standard deviation.

RESULTS AND DISCUSSIONS

Group 1 included 12 males and 10 females and Group 2 included 16 males (2 neutered) and 12 females (6 neutered).

In Group 1 the mean age was 8,16 years, with a range from 4,2 years to 11,1 years old and the mean value for systolic blood pressure was 122 ±12 mmHg; the mean value for R.I. and P.I. was 0.70 ±0.35 and respectively 1.13 ± 0.13. No differences were found between right and left kidney index, and no correlation between systolic blood pressure and R.I. and P.I.. We suggest an upper limit (calculated as mean + standard deviation) for R.I. and P.I. at 0.74 and respectively 1.27.

Torroja et colab. in 2004 suggest an upper value of 0.73 for R.I. and respectively 1.52 for P.I. on unsedated healthy dogs.

Group 2 included dogs with different renal disease. Fifteen cases were diagnosed with chronic renal failure (CRF), 6 cases with acute renal failure (ARF) and 7 with other renal diseases (including 2 cases with hydronephrosis, 2 with renal cysts and 3 neoplasia cases). In this group the mean age was 9,06 years ± 2.34 years, with a range from 3,2 years to 13,1 years old. The mean value for systolic blood pressure was 132 ±11 mmHg. In dogs with CRF, ARF and other

kidney diseases, we obtained the mean value for R.I. 0.84 ± 0.15, 0.5 ±0.13, 0.56 ±0.13 (Table 1) and respectively for P.I. 1.35 ±0.21, 0.85 ±0.24, 1.22±0.07 (Table 2).

Significant differences were found between R.I. ($P<0.05$) and P.I. ($P<0.05$) values from the Group 1 and dogs with CRF from the Group 2. Reduced differences were found between values of R.I. ($P>0.05$) and significant differences were found regarding P.I values ($P<0.05$) between the Group 1 and the dogs with ARF from the Group 2; and between R.I. ($P<0.05$) and P.I ($P<0.05$) values of the Group 1 and dogs with other renal diseases from the Group 2. No correlation was found between systolic blood pressure and either of the R.I. and P.I. in both groups.

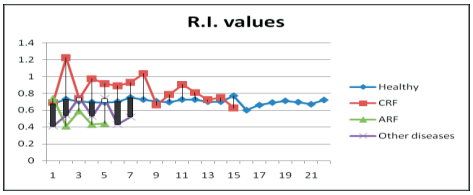

Figure 1. Values of resistive index (R.I.) in healthy dogs and dogs with renal diseases (CRF - chronic renal failure, ARF - acute renal failure).

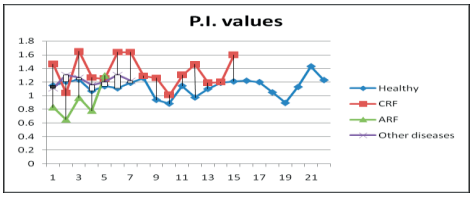

Figure 2. Values of pulsatory index (P.I.) in healthy dogs and dogs with renal diseases (CRF - chronic renal failure, ARF - acute renal failure).

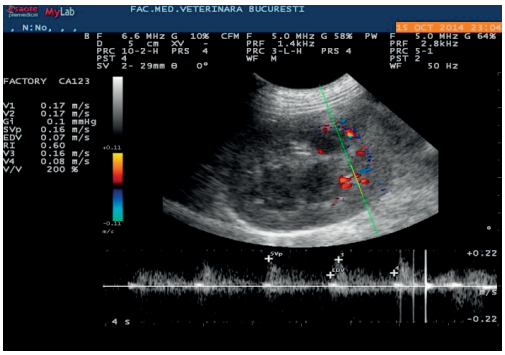

Figure 3. Doppler ultrasound image showing sample location (arcuate artery) and pulse wave in one dog with chronic renal failure

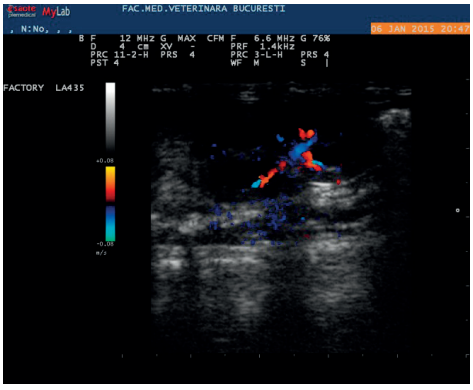

Figure 4. Doppler ultrasound image showing vascularization of the kidney.

The cases which presented renal diseases in comparison with the healthy ones, may show an increased value of the R.I. and P.I..

The R.I. was increased in 70% of all cases diagnosed with chronic renal failure, 8% from the acute renal failure and 14% of cases with other renal disease.

P.I. values were increased in 57% of all cases diagnosed with chronic renal failure, 17% from the acute renal failure and 36% of cases with other renal disease.

Table 1. Value and percentage of resistive index for Group 1 and Group 2, standard deviation.

Clinical status / Nr.	Group 1			Group 2								
	Healthy dogs			CRF			ARF			Other kidney diseases		
	R.I. value left kidney	R.I. value right kidney	Mean value R.I.	R.I. value left kidney	R.I. value right kidney	Mean value R.I.	R.I. value left kidney	R.I. value right kidney	Mean value R.I.	R.I. value left kidney	R.I. value right kidney	Mean value R.I.
1	0.67	0.68	0.675	0.68	0.7	0.69	0.76	0.72	0.74	0.42	0.4	0.41
2	0.74	0.72	0.73	1.21	1.24	1.225	0.4	0.42	0.41	0.56	0.52	0.54
3	0.71	0.7	0.705	0.72	0.75	0.735	0.62	0.56	0.59	0.76	0.74	0.75
4	0.68	0.71	0.695	0.99	0.96	0.975	0.42	0.44	0.43	0.52	0.54	0.53
5	0.7	0.68	0.69	0.92	0.91	0.915	0.46	0.42	0.44	0.72	0.76	0.74
6	0.71	0.69	0.7	0.9	0.88	0.89	0.38	0.4	0.39	0.42	0.44	0.43
7	0.76	0.74	0.75	0.92	0.94	0.93				0.51	0.53	0.52
8	0.72	0.73	0.725	0.99	1.08	1.035						
9	0.71	0.7	0.705	0.65	0.67	0.66						
10	0.69	0.7	0.695	0.78	0.79	0.785						
11	0.72	0.73	0.725	0.89	0.92	0.905						
12	0.74	0.71	0.725	0.8	0.82	0.81						
13	0.7	0.7	0.7	0.69	0.76	0.725						
14	0.69	0.71	0.7	0.74	0.76	0.75						
15	0.78	0.76	0.77	0.62	0.63	0.625						
16	0.58	0.62	0.6									
17	0.64	0.68	0.66									
18	0.68	0.7	0.69									
19	0.72	0.7	0.71									
20	0.7	0.69	0.695									
21	0.66	0.68	0.67									
22	0.73	0.71	0.72									
R.I. mean value	0.7013	0.7018	0.701	0.8333	0.854	0.8436	0.5066	0.4933	0.5	0.5585	0.5614	0.56
Upper limit for R.I.	**0.736694953 (Total mean R.I. + standard deviation)**			**<=0.74**	**> 0.74**		**<= 0.74**	**> 0.74**		**<=0.74**	**> 0.74**	
	Nr. of examined kidneys			9	21		11	1		12	2	
	Percentage			30%	70%		92%	8%		86%	14%	
Total mean R.I.	0.701590909			0.843666667			0.5			0.56		
Standard Deviation	±0.035104043			±0.159081054			±0.132390607			±0.131324612		
P				P=**0.004253085**			P=**0.015271**			P=**0.032874**		

Table 2. Value and percentage of pulsatory index for Group 1 and Group 2, standard deviation.

Clinical status / Nr.	Group 1			Group 2								
	Healthy dogs			CRF			ARF			Other kidney diseases		
	P.I. value left kidney	P.I. value right kidney	Mean value P.I.	P.I. value left kidney	P.I. value right kidney	Mean value P.I.	P.I. value left kidney	P.I. value right kidney	Mean value P.I.	P.I. value left kidney	P.I. value right kidney	Mean value P.I.
1	1.17	1.13	1.15	1.45	1.48	1.465	0.8	0.86	0.83	1.12	1.1	1.11
2	1.23	1.18	1.205	1.02	1.06	1.04	0.62	0.68	0.65	1.29	1.32	1.305
3	1.21	1.26	1.235	1.62	1.68	1.65	0.96	0.98	0.97	1.24	1.28	1.26
4	1.02	1.12	1.07	1.25	1.28	1.265	0.8	0.76	0.78	1.17	1.14	1.155
5	1.16	1.12	1.14	1.26	1.24	1.25	1.29	1.3	1.295	1.18	1.22	1.2
6	1.2	1.02	1.11	1.66	1.62	1.64	0.58	0.6	0.59	1.32	1.29	1.305
7	1.24	1.14	1.19	1.6	1.68	1.64				1.23	1.21	1.22
8	1.2	1.32	1.26	1.28	1.3	1.29						
9	0.99	0.89	0.94	1.27	1.25	1.26						
10	0.98	0.79	0.885	1.01	1	1.01						
11	1.2	1.09	1.145	1.29	1.32	1.305						
12	0.87	1.08	0.975	1.5	1.42	1.46						
13	1.08	1.12	1.1	1.26	1.12	1.19						
14	1.14	1.24	1.19	1.22	1.18	1.2						
15	1.24	1.18	1.21	1.58	1.62	1.6						
16	1.28	1.16	1.22									
17	1.18	1.22	1.2									
18	1.02	1.08	1.05									
19	0.89	0.9	0.895									
20	1.02	1.24	1.13									
21	1.48	1.38	1.43									
22	1.24	1.22	1.23									
P.I. mean value	**1.138**	**1.130**	**1.134**	**1.351**	**1.35**	**1.35066**	**0.841**	**0.863**	**0.8525**	**1.221**	**1.222**	**1.222142**
Upper limit for P.I.	**1.273452393 (Total mean P.I. + standard deviation)**			**<=1.27**	**> 1.27**		**<= 1.27**	**> 1.27**		**<=1.27**	**> 1.27**	
	Nr. of examined kidneys			13	17		10	2		9	5	
	Percentage			**43%**	**57%**		**83%**	**17%**		**64%**	**36%**	
Total mean P.I.	**1.134**			**1.350666667**			**0.8525**			**1.222142857**		
Standard Deviation	**±0.138906938**			**±0.212017132**			**±0.244098527**			**±0.072767128**		
P				P=**0.002113222**			P=**0.041497980**			P=**0.037828911**		

CONCLUSIONS

The evaluation of renal vascular index represents an useful technique in guiding the diagnosis.
The correlation between the blood pressure and the renal vascular index in healthy dogs and in cases with various renal diseases could not been established.

Dogs with renal diseases may present an increased R.I. and P.I..

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