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Radiographic Liver Size Evaluation after Portosystemic Shunts Ligation in 13 Cases

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Abstract : Thirteen dogs were diagnosed as congenital extrahepatic single PSS by intraoperative mesenteric portovenography or computed tomographic examination, repair surgery was performed by using an ameroid constrictor. Hepatic size was measured from the right lateral view using liver length/T11 length ratio. This measurement was performed on follow-up check of PSS ligation patients. Hepatic size parameter of pre-operative PSS patients is 4.13 ± 0.13 (range, 3.11-4.83). After surgery, hepatic size parameter of post-operative PSS patients is 4.79 ± 0.19 (range, 3.78-5.93). Although follow-up periods varied 2 and 26 weeks, all patients showed increased liver size compared to that on pre-operative radiographs ($P < 0.01$). The increase rate was 1.01-1.46 times than those of preoperative radiographs. But in 5 patients, post hepatic liver size was small compared to the others, which showed low increase rate of body weight, total protein, albumin, and glucose level. It was thought that small value of hepatic size parameter was due to delay of hepatic regeneration. In conclusion, radiographic hepatic size parameter of pre- and post-operative patients is considered an effective evaluation for restoring after PSS surgery.

Key words **:** PSS, radiography, hepatic size, dog.

Introduction

Congenital portosystemic shunts (PSS) is one of the most common congenital vascular disorder. PSS are abnormal connections between the portal system (splenic, phrenic, cranial mesenteric, caudal mesenteric, gastric, or gastroduodenal veins) to the caudal vena cava or azygos vein (2). The portal blood bypasses the hepatic sinusoids and enters directly into the systemic circulation. The resulting reduction of portal blood flow and therefore reduction of hepatotrophic factors such as insulin, glucagon derived from the gastrointestinal tract and pancreas results in poor hepatic development, macroscopic and microscopic liver hypoplasia (2,10). Therefore, microhepatia on abdominal radiograph is a typical finding with PSS patients (2,8,10,14).

Congenital PSS largely divided into two categories such as intrahepatic and extrahepatic shunts accordingly location of shunt vessel (13,14). In dogs and cats, approximately 66% to 75% of congenital PSS are single extrahepatic shunt, with a major solitary portocaval shunt being the most common (13, 14). Most extrahepatic PSS are seen in smaller breeds, odds ratio for PSS in Yorkshire terriers was 35.9 times greater than for all other breeds combined (13). Clinical signs secondary to PSS are hepatic encephalopathy, chronic gastrointestinal and lower urinary tract signs. Poor hepatic development and atrophic hepatocytes results in impaired hepatic function, accumulated body with exogenous and endogenous toxins such as ammonia that are normally detoxified through the liver (2,10).

Survey abdominal radiographs of PSS patients often showed microhepatia and bilateral renomegaly, but these are suggestive of but not diagnostic for PSS. Congenital PSS definitely diagnosed by various techniques including scintigraphy, mesenteric portovenography, dual-phase computed tomography (CT), magnetic resonance angiography (MRA) and exploratory surgery (2,14). And there are medical and surgical methods of treatment after diagnosed for congenital PSS. Medical managements that include antibiotics, lactulose, anticonvulsants, and hepatosupports minimize the exogenous and endogenous toxins gastrointestinal-derived factors entering the systemic circulation. And surgical shunt attenuation is to redirect blood through the parenchyma of the liver (2,4,14). Previous report revealed that 51.9% cases of medical management of congenital PSS had long-term survival, whereas 87.9% cases receiving surgical treatment had (4).

In human medicine, liver volume is useful and safe in predicting the final outcome of liver failure, and in veterinary medicine, hepatic and portal regeneration after surgery may be important prognostic marker (5,11). Therefore, the purpose of the present study is to compare liver size between the pre- and post-operative patients and to apply standardized hepatic size parameter as an additive follow-up factor after PSS ligation.

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Materials and Methods

Medical records of all 13 dogs that performed surgery for a congenital single extrahepatic PSS between August 2005 and December 2015 at the Seoul National University Veterinary Medical Teaching Hospital were reviewed. They were confirmed by intra-operative mesenteric portovenography or CT angiography as single PSS. All patients underwent abdominal radiography, ultrasonography, and blood analyses. Data obtained retrospectively from the medical records of all dogs included breed, sex, age at the time of diagnosis and surgery, clinical signs, serum biochemistry results, location of the shunt (portocaval or portoazygos), and postsurgical clinical course.

Hepatic size parameter was defined as a ratio of liver length/ T11 vertebral length, in order to compare values of dogs with different body weights and of different sizes (1). On right lateral radiographs, liver length and the length of the 11^{th} thoracic vertebra were acquired. Liver length was surveyed as the length of the axis of from ventral border of caudal vena cava to the apex of hepatic caudoventral border. The length of T11 vertebra was surveyed at the level of the midpoint parallel to the long axis of the vertebral body (Fig 1). Conventional films were assessed using radiographic view boxes and digital images were evaluated on a DICOM viewer. Measurements for conventional films were made using manual calipers and measurement for DICOM images were made using electronic calipers. All measurements were performed three times by two of the authors for the reliability of the results.

Pre- and post-operative data were compared with inclusion the following results: hepatic size parameter, serum liver enzymes including alanine aminotransferase (ALT), aspartate aminotransferase (AST), alkaline phosphatase (ALP), gamma-glutamyl transferase (GGT), ammonia (NH_3), total protein (TP), albumin, glucose, cholesterol, blood urea nitrogen (BUN), bile acid (pre- and post-prandial), and mean cell volume (MCV). All the values were expressed as mean ± standard deviation (SD). Nonuniform hematologic parameters were available due to inherent retrospective nature.

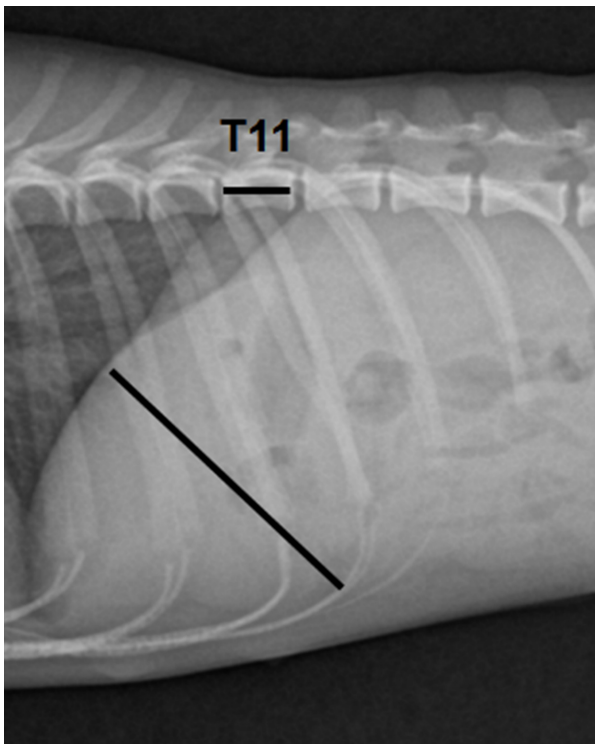

Fig 1. Right lateral abdominal radiographs demonstrating the measuring methods for liver length and length of the 11^{th} thoracic vertebra.

Statistical analyses were performed with standard software (IBM SPSS Statistics, IBM Corp., Armonk, NY). Likelihood ratios (and 95% confidence intervals) were calculated for results with $P < 0.05$. It was probability that there was no relationship or no difference. Blood analyses results before and after surgery were compared using a paired Student's t test. And using ICC (intra-class correlation coefficient) statistics assessed the inter- and intra-observer agreement. The value of ICC was determined as follows: > 0.75 was excellent, 0.40-0.75 was fair to good, < 0.40 was poor (3).

Results

Total 13 cases were included in this study; 8 dogs (62%) were female, 3 (23%) were male, and 2 (15%) were castrated male. Breeds were Maltese (8) Shih-tzu (2), and 1 each of Toy Poodle, Bichon Frise, Yorkshire terrier. Mean age at diagnosis was 14 months (range, 4-30 months), and mean weight was 1.90 kg (range, 1.27-2.87 kg). The shunt type of congenital extrahepatic PSS consisted of 11 portocaval shunts and 2 portoazygos shunts. Clinical signs included encephalopathic episodes (13/13) were signs of seizure (6/13), depression and lethargy (6/13), ataxia (4/13), ptylalism (2/13), vomiting (5/13), anorexia (2/13), hematuria (4/13), and urinary obstruction (1/13). All surgeries were performed by the same surgeon using ameroid ring constrictor. After surgery, all patients had improvement of clinical signs except 1 patient that had intermittent episodes of seizure after 2 months of surgery.

The mean values of the blood test results recorded pre- and post-operation are summarized in Table 1. All of the blood analyses results were improved compared to pre- and post-operative results. The following parameters showed a significant improvement: ALT, AST, NH_3, Total protein, Albumin, and MCV. Although the other parameters did not show significant changes after surgery, those were improved.

The median follow-up period for the 13 dogs was 8 weeks with a range from 2 to 16 weeks (mean ± SD, 8.77 ± 1.89 weeks). And the follow-up frequencies were 1 to 3 times.

The pre- and post-operative hepatic size parameters (mean ± SD) were 4.13 ± 0.13 with a range from 3.11 to 4.83, and 4.79 ± 0.19 with a range from 3.78 to 5.93, respectively ($P < 0.01$). All patients had increase of hepatic size parameter and the rates of increase were 1.01 to 1.47 times. The pre- and post-operative hepatic size parameters, rate of increase of all patients and breeds were recorded (Table 2).

In pre- and post-operative groups, significantly difference in hepatic size parameter, serum chemistry results (ALT, AST, NH_3, TP, and Albumin), CBC results (MCV) between the both groups ($P < 0.05$). And the value of inter- and intra-observer agreement was > 0.8 ($P < 0.05$).

Table 1. Blood analysis results of pre- and post-operative groups (mean ± SD)

Blood analysis parameter	Pre-OP	Post-OP	Reference Range (unit)	P value
ALT (n = 13)	228.38 ± 57.4	53.55 ± 4.91	6-90 (U/L)	0.01
AST (n = 13)	169.36 ± 40.45	37.08 ± 2.54	10-43 (U/L)	0.008
ALP (n = 13)	682.0 ± 234.80	240.08 ± 36.98	8-100 (U/L)	0.076
GGT (n = 12)	13.75 ± 1.96	9.44 ± 1.17	0-14 (U/L)	0.073
NH_3 (n = 5)	152.60 ± 22.83	39.4 ± 15.10	2.6-4.0 (mg/dl)	0.009
T. chol (n = 1)	93.0	175.0	112-312 (mg/dl)	-
TP (n = 8)	4.60 ± 0.14	5.34 ± 0.22	5.2-8.2 (g/dl)	0.023
Albumin (n = 9)	2.59 ± 0.13	2.95 ± 0.15	2.6-4.0 (g/dl)	0.01
BUN (n = 8)	7.46 ± 0.98	9.93 ± 1.66	8-32 (mg/dl)	0.156
Glucose (n = 6)	72.83 ± 6.81	83.83 ± 6.22	60-120 (mg/dl)	0.066
Pre BA (n = 2)	50.50 ± 24.50	6.50 ± 1.50	0-10 (μmol/l)	0.076
Post BA (n = 1)	104.0	40.0	0-20 (μmol/l)	-
MCV (n = 8)	60.14 ± 2.22	63.08 ± 1.62	58.8-71.2 (fl)	0.039

Abbreviations: OP, operation; ALT, alanine aminotransferase; AST, aspartate aminotransferase; ALP, alkaline phosphatase; GGT, gamma-glutamyl trasnsferase; T. chol, total cholesterol; TP, total protein; BUN, blood urea nitrogen; BA, bile acid.

Table 2. Hepatic size parameter of pre- and post-operative and the rate of increase in both groups

	Breeds	Pre-OP	Post-OP	The increase rate
Case 1	Yorkshire terrier	3.56	3.78	1.06
Case 2	Maltese	3.11	4.56	1.47
Case 3	Shih-tzu	4.51	4.59	1.02
Case 4	Shih-tzu	4.50	5.22	1.16
Case 5	Maltese	3.94	4.70	1.19
Case 6	Bichon Frise	4.2	4.27	1.02
Case 7	Maltese	4.31	5.39	1.25
Case 8	Poodle	4.18	5.65	1.35
Case 9	Maltese	4.44	5.93	1.34
Case 10	Maltese	4.49	5.05	1.12
Case 11	Maltese	4.83	5.33	1.10
Case 12	Maltese	3.77	4.01	1.06
Case 13	Maltese	3.79	3.81	1.01

Discussion

This study was designed to include medical records of all dogs with a single extrahepatic PSS that were treated by surgical ligation with an ameroid ring constrictor. Performing pre- and post-operative radiographs in dogs with congenital PSS allowed to obtain clinically relevant results of liver size. All patients had increase of hepatic size parameter compared to pre- and post-operative radiograph.

In several study of prognostic factors for PSS ligation, preoperative body weight, serum chemistry (TP, ALB, and BUN), age at initial signs, and portal pressure were reported (7,9,15). Post-operative prognostic factors were reported including post-operative seizures, serum bile acids, and hepatic volume (7,12,14).

This study showed the value of pre-operative hepatic size parameter with congenital PSS dogs. The value was 4.13 ± 0.13 (mean ± SD). For using this value with suspected congenital PSS patients, it should be clarified by conducting a further study with a large sample size.

And in a previous study of hepatic size parameter calculated, Choi et al. reported that hepatic size parameter of normal different breeds. The hepatic size parameter of non-brachycephalic group including Maltese, Poodles, Yorkshire terrier, and Pomeranian was 5.4 ± 0.74, the parameter of non-Pekingese brachycephalic group including Shihtzu, Pug, and Boston terrier was 5.16 ± 0.74, and the parameter of Pekingese was 4.64 ± 0.65 (1). The lower limit of hepatic size parameter for nonbrachycephalic and brachycephalic breeds was 4.66 and 4.42, respectively. These were used cutoff value of normal liver size. As a result, the five dogs of post-surgery (Case 1, 2, 6, 12, and 13) did not approach the normal hepatic size parameter. For find out in relation to this, comparison of these dogs and the others was performed about blood analyses results in pre- and post-operation. The small value group of hepatic size parameter represented that lower increase rate of body weight, TP, ALB, and glucose level. And the one of five dogs showed the post-operative seizures. Total protein, albumin, and glucose concentration in serum were considered as hepatobiliary system function parameters (8).

The small value group of hepatic size parameter did not showed significant clinical signs except one dog. But, it was possible to delay of hepatic regeneration, so they were need regular and serial recheck and to check delayed portal hypertension. Acute and chronic portal hypertension may be seen in patients undergoing shunt ligation and persistent portosystemic shunting were encountered (14). And four of five dogs of small value of hepatic size parameter were noticed that

they had small value of pre-operative hepatic size parameter. It was undetermined in this study that pre-operative hepatic size parameter affected the post-operative hepatic size parameter, so further establishment required about this.

And there was no apparent correlation between the increase rate of hepatic size parameter and blood analyses results or follow-up periods in this study.

In previous studies, they were showed hepatic volume measurements in dogs with PSS pre- and post-surgical attenuation using CT and liver volume increased after surgery (6,12). Comparing to this method, hepatic size parameter using radiographic measurements is a safe, convenient and rapid method without general anesthesia.

This study is a retrospective design, which has inherent limitations. There were a small number of cases that use of pre- and post-operative radiograph and blood analyses results. And given the retrospective nature of study, all dogs had variable recheck frequencies and times and lost to follow-up monitoring. Additionally, there was no data about histopathologic exam of liver at pre- and post-operative examinations. Correlation with radiographic and histopathologic results should be needed. And it is necessary to evaluate hepatic function tests such as serum bile acid test for pre- and post-operative status. So, newly designed prospective study that standardized regular recheck for hepatic size parameter, hepatic function tests, and histopathologic examination are mandatory, if possible. And there would be re-evaluated among large population.

A larger prospective study is also required to further establish the relationship of hepatic size parameter and prognosis after the surgery. Despite these shortcomings, the results of this study will help surgeon and radiologists to evaluate liver restoring after PSS surgery and application for additional follow-up factor.

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