

Clinical and laboratory outcome after surgical treatment of single congenital extrahepatic portosystemic shunt using ameroid constrictor in 25 dogs

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Received August 10, 2020

Accepted December 21, 2020

Abstract

The objective of the study was to evaluate the clinical and laboratory outcome after the surgical treatment of a single congenital extrahepatic portosystemic shunt using an ameroid constrictor. Patient medical records were reviewed in retrospect. Data on the signalment, clinical signs, preoperative bile acid stimulation test and ammonia concentration were recorded. The surgical treatment success rate was evaluated by mortality in the perioperative and short-term postoperative period and by the long-term clinical outcome. Bile acid stimulation test and ammonia concentration were also analysed 2–3 days, 4–6 weeks, and 6–8 weeks postoperatively. No patient died in the selected periods. The long-term clinical outcome was excellent in 15 out of 20 patients, good in 3 out of 20 patients and poor in 2 out of 20 patients. Preprandial bile acid concentration was elevated in 96.00%, postprandial bile acid concentration in 100.00% and ammonia concentration in 80.95% of patients preoperatively. A significant decrease was found in postprandial bile acid and ammonia 2–3 days postoperatively and in preprandial bile acid 4–6 weeks postoperatively. A significant decrease in liver function parameters in days post operation indicates a rapid restoration of hepatic function. The surgical treatment of a single extrahepatic portosystemic shunt using an ameroid constrictor is a successful method of treatment for this type of portosystemic shunt, with as much as 75.00% of the patients having an excellent long-term clinical outcome.

PSS, bile acid, bile acid stimulation test, ammonia, liver

Portosystemic shunt (PSS) is a vascular system anomaly in which there is communication between portal and systemic circulation. Single congenital extrahepatic portosystemic shunt (SEHPSS) in dogs is typically found in small breeds, e.g. the Yorkshire Terrier, West Highland White Terrier, Maltese, Miniature Schnauzer, Shih Tzu or Pug (Hunt and Hughes 1999; Burton and White 2001; Murphy et al. 2001; Tobias and Rohrbach 2003; Hunt 2004; Mehl et al. 2005; Greenhalgh et al. 2010; Falls et al. 2013; Bristow et al. 2017; Traverson et al. 2018). Surgical treatment is currently the method of choice in the therapy of this disease, especially because of its curative effect in contrast to medical therapy (Greenhalgh et al. 2010). For surgical treatment, the use of methods ensuring gradual vascular occlusion, such as ameroid constrictor placement, is preferred over the classic ligation of the shunt (Hunt and Hughes 1999; Mehl et al. 2005; Falls et al. 2013; Bristow et al. 2017; Traverson et al. 2018). Surgical mortality after ameroid constrictor placement for shunt occlusion in dogs with SEHPSS varies from 0% to 7.3% (Murphy et al. 2001; Mehl et al. 2005; Falls et al. 2013; Hunt et al. 2014; Traverson et al. 2018).

Assessment of plasma or serum bile acid (BA) and ammonia concentration plays an important role in the diagnostics of PSS (Schlesinger and Rubin 1993). In dogs and cats with PSS, the sensitivity of fasting BA concentration is 88.90–93.00%, the specificity is

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67.00–67.90% (Gerritzen-Bruning et al. 2006; Ruland et al. 2010). Sensitivity can be increased by conducting postprandial BA measurements (Schlesinger and Rubin 1993). Plasma or serum ammonia concentration sensitivity in detecting PSS is 85.00–98.00% and the specificity is 86.00% (Gerritzen-Bruning et al. 2006; Ruland et al. 2010). Assessment of these two parameters can be used not only for diagnosing PSS, but also for the postoperative monitoring of patients. From the clinical point of view, it is the least invasive approach to evaluate the PSS closure after surgery, despite the fact that the elevated BA concentration does not correlate with the PSS closure in 100.00% of cases (Vogt et al. 1996). Nevertheless, it was found that a persistent elevation of serum BA in patients after surgical ligation of PSS was due to the presence of PSS either in the form of persistent shunting through the original PSS or persistent shunting combined with multiple acquired PSS (Burton and White 2001).

The first aim of this study was to determine the success rate of the surgical treatment of SEHPSS using an ameroid constrictor not only in the early postoperative period, but also in the long-term postoperative period. Criteria used for the success rate assessment were perioperative and postoperative mortality and the patient's long-term clinical outcome. The second aim of the study was to evaluate changes in plasma BA and ammonia concentrations before and after surgery of SEHPSS using an ameroid constrictor.

Materials and Methods

The retrospective study was conducted by reviewing medical records of dogs with SEHPSS that underwent surgical treatment using an ameroid constrictor at the Department of Surgery & Orthopaedics at the Small Animal Clinic, Faculty of Veterinary Medicine, University of Veterinary and Pharmaceutical Sciences Brno, Czech Republic, from January 2013 to July 2017. A diagnosis of SEHPSS was made based on the clinical examination, haematological and biochemical analyses (including BA stimulation test and/or ammonia concentration measurements) and diagnostic imaging (abdominal ultrasonography and/or computed tomography angiography). The patient's breed, sex, age and weight at the time of surgery were recorded. Additionally, subjective assessment of the patient's clinical signs was performed on the basis of communication with the owners at the initial examination of the patient prior to surgery. These clinical signs were subcategorized as neurological (ataxia, disorientation, circling, spasms, head pressing, ptialism, tremor), gastrointestinal (vomiting, diarrhoea) and urological (clinical signs associated with cystitis and urolithiasis – dysuria, haematuria, pollakiuria, stranguria, polyuria/polydipsia).

Midline laparotomy was performed under general anaesthesia and SEHPSS was identified during abdominal exploration. Surrounding adventitia was bluntly dissected around SEHPSS. An ameroid constrictor of appropriate size (2.5 mm, 3.5 mm, 5.0 mm, 6.0 mm or 7.0 mm) was placed on the SEHPSS in such a manner that no immediate reduction of the vessel diameter was caused by the placement. The abdominal wall, subcutaneous tissues and skin were closed in a standard manner. The patients were discharged from the hospital 2–6 days after the surgery (depending on their clinical status) with the following medication: amoxicillin clavulanate (Noroclav 12.50 mg/kg orally, Norbrook Laboratories Limited, Newry, Northern Ireland) twice daily for 7 days, and lactulose (Duphalac 0.50 ml/kg orally, Abbott Healthcare Product B.V., Netherlands) three times daily until the follow-up visit at 6–8 weeks after the surgery. The owners were also instructed to feed their dog a hepatic diet until the follow-up.

The success rate of the surgical treatment was evaluated on the basis of mortality during the perioperative period (from the induction of anaesthesia to the patient's complete recovery from anaesthesia) and during the short-term postoperative period (< 2 months after surgery), and also on the basis of the patient's clinical outcome in the long-term postoperative period (≥ 6 months after surgery) by a telephone interview with the owner. During the telephone interview, the owners were asked whether their dog had any clinical signs of the disease, what type of diet the dog was being currently fed (low-protein diet = hepatic diet/regular commercial dog food) and whether it was receiving any medications for PSS (antibiotics, anticonvulsant, lactulose). According to the owner's answers, the patient's clinical outcome was classified according to Mehl et al. (2005) as:

- Excellent – patient is clinically healthy and not receiving any form of medical treatment;
- Good – patient is clinically healthy but receiving a low-protein diet, antimicrobials, anticonvulsants, or a combination of these treatments;
- Poor – patient continues to have clinical signs of the disease or patient died because of PSS.

For the purpose of the study, the results of BA stimulation test and plasma ammonia concentrations were reviewed in selected periods, namely, before the surgery, 2–3 days, 4–6 weeks and 6–8 weeks after the surgery. These variables were analysed on Architect c4000 analyser (Abbott laboratories, Illinois, USA). The reference values for healthy dogs stated in our laboratory are as follows: preprandial plasma BA < 10.00 µmol/l, postprandial

plasma BA < 15.00 $\mu\text{mol/l}$, ammonia < 30.00 $\mu\text{mol/l}$. Preprandial plasma BA concentrations, postprandial plasma BA concentrations, and plasma ammonia concentrations obtained before the surgery and in the selected periods were statistically analysed using a commercial software (Minitab 16, Minitab Inc, Coventry, Great Britain). Data were analysed with ANOVA and post hoc Tukey test. Results of plasma BA concentrations stated as < 0.50 $\mu\text{mol/l}$ and ammonia concentrations stated as < 4.70 $\mu\text{mol/l}$ were excluded from the statistical analysis because of impossibility to determine the exact numerical value.

Results

Twenty-five dogs with SEHPSS treated surgically with an ameroid constrictor between January 2013 and July 2017 at the Department of Surgery & Orthopaedics at the Small Animal Clinic, Faculty of Veterinary Medicine, University of Veterinary and Pharmaceutical Sciences Brno, met the inclusion criteria for the study. The study population characteristics (breed, sex, weight, age and SEHPSS type) are shown in Table 1. The mean body weight was 3.86 kg (standard deviation [SD] 3.30), the mean age was 23.04 months (SD 27.67). Neurological signs were reported in 17 patients (68.00%), gastrointestinal signs in two patients (8.00%), neurological in combination with urological signs in two patients (8.00%), neurological in combination with gastrointestinal signs in two patients (8.00%) and urological in combination with gastrointestinal signs in two patients (8.00%).

Table 1. Study population characteristics – breed, sex, weight, age (at the time of surgery) and single extrahepatic congenital portosystemic shunt type (according to Fossum 2007).

Patient	Breed	Sex	Weight (kg)	Age (months)	SEHPSS type
1	YT	F	0.75	4.5	portocaval
2	YT	F	1.40	5.5	portocaval
3	Crossbreed	M	1.50	4.5	portocaval
4	YT	M	1.70	4.5	portocaval
5	YT	MC	4.70	102	gastrocaval
6	Maltese	F	1.50	14	portocaval
7	JRT	M	2.00	7.5	portocaval
8	WHWT	F	4.00	4	portocaval
9	Biewer Terrier	F	1.95	6	portocaval
10	Prague Ratter	F	4.00	71	portoazygos
11	YT	F	3.30	25	portoazygos
12	Dachshund	M	7.60	38	portocaval
13	YT	F	1.30	5	portocaval
14	YT	F	2.25	74	portocaval
15	Border Collie	F	12.10	27	portocaval
16	WHWT	F	6.30	7	portocaval
17	YT	M	1.70	6	portocaval
18	YT	F	2.65	4	portocaval
19	Pug	M	6.60	3	portocaval
20	YT	F	0.80	3	portocaval
21	YT	F	2.00	7.5	portocaval
22	Miniature Schnauzer	F	13.30	23	portoazygos
23	YT	F	2.20	33	splenicaval
24	YT	M	5.00	26	portocaval
25	YT	M	6.00	71	splenicaval

YT - Yorkshire Terrier; JRT - Jack Russel Terrier; WHWT - West Highland White Terrier; F - female; M - male; MC - male castrated

The surgery was performed by the same surgeon (JL) in all 25 patients. No patient died during the perioperative or short-term postoperative period. Information on the long-term clinical outcome was obtained for 20 of 25 patients enrolled in the study as we were not able to contact the owners of the remaining five patients. The long-term clinical outcomes are presented in Table 2. Two out of 20 patients (10.00%) still showed mild clinical signs of the disease during the long-term follow-up. It was occasional tremor postprandially in one patient and occasional signs of disorientation in the other one. The patients that were not fed a diet suitable for patients with hepatic disease (hepatic diet) were fed a standard commercial diet (dry or canned food), homemade meal or a combination of both. Only three patients were fed a hepatic diet in the long-term follow-up. The reason for feeding the patients a hepatic diet (despite the recommendations) was the patient's or owner's preference, not a medical reason. According to the criteria for long-term clinical outcome assessment described by Mehl et al. (2005), 15 out of 20 patients (75.00%) had an excellent clinical outcome, 3 patients (15.00%) had a good clinical outcome, and 2 patients (10.00%) had a poor long-term clinical outcome after surgery.

Table 2. Long-term clinical outcome after surgery of single extrahepatic portosystemic shunt using ameroid constrictor.

Patient	Sex	Age at the time of surgery (months)	Weight at the time of surgery (kg)	Time from surgery (months)	Clinical signs	Type of food	Medication
1	M	4.5	1.50	9	no	C	no
2	M	4.5	1.70	12	no	C + HM	no
3	M	102	4.70	12	no	C	no
4	F	14	1.50	13	no	C	no
5	M	7.5	2.00	14	no	C	no
6	F	4	4.00	14	no	HM	no
7	M	6	1.70	15	yes	C	no
8	F	6	1.95	21	yes	C	no
9	F	71	4.00	21	no	C	no
10	M	38	7.60	21	no	C	no
11	F	5	1.30	26	no	C	no
12	F	74	2.25	33	no	C	no
13	F	27	12.10	34	no	C	no
14	F	7	6.30	34	no	C	no
15	F	4	2.65	40	no	C + H	no
16	F	3	0.80	41	no	C	no
17	M	3	6.60	44	no	C + H	no
18	F	33	2.20	46	no	C	no
19	M	71	6.00	55	no	C + H	no
20	M	26	5.00	61	no	C + HM	no

M - male; F - female; C - commercial diet; H - hepatic diet; HM - homemade diet

During the preoperative examination, BA stimulation test was conducted in all 25 patients and plasma ammonia concentration was measured in 21 patients. Preprandial BA concentration was elevated in 24 patients (96.00%) and postprandial BA concentration was elevated in all 25 patients (100.00%) before surgery. Plasma ammonia concentration was elevated in 17 out of 21 patients (80.95%) before surgery. BA stimulation test was conducted in all 25 patients in the period of 2–3 days after surgery, in 14 patients in the

period of 4–6 weeks after surgery and in 12 patients in the period of 6–8 weeks after surgery. Postprandial BA concentrations were within the normal reference range in 7 out of 25 patients (28.00%) within 8 weeks postoperatively. Plasma ammonia concentration was measured in 16 patients in the period of 2–3 days after surgery, in 10 patients in the period of 4–6 weeks after surgery and in nine patients in the period of 6–8 weeks after surgery. Plasma ammonia concentrations were within the normal reference range in nine patients (42.86%) within 8 weeks postoperatively. There was a significant difference in preprandial ($P = 0.01$) and postprandial BA concentrations ($P = 0.001$) and in plasma ammonia concentration ($P = 0.002$) between the selected periods (Table 3). There was a significant decrease in postprandial BA in the period of 2–3 days after surgery. On the other hand, a significant decrease in preprandial BA concentration was found in the period of 4–6 weeks after surgery. A significant decrease in plasma ammonia concentration was also found in the period of 2–3 days after surgery.

Table 3. Mean (standard deviation) bile acid (BA) and ammonia concentrations in the selected time periods.

Indicator	Before surgery	2-3 days after surgery	4-6 weeks after surgery	6-8 weeks after surgery	Reference values
Ammonia ($\mu\text{mol/l}$)	98.74 ^a (60.312) n = 21	41.16 ^b (33.193) n = 15	30.91 ^b (30.894) n = 9	32.64 ^b (49.887) n = 8	< 30.00
Preprandial BA ($\mu\text{mol/l}$)	139.46 ^a (158.06) n = 25	146.34 ^a (169.19) n = 19	9.17 ^b (20.826) n = 10	47.02 ^{ab} (20.986) n = 8	< 10.00
Postprandial BA ($\mu\text{mol/l}$)	324.31 ^a (222.06) n = 25	164.90 ^b (198.90) n = 23	93.32 ^b (137.56) n = 13	101.43 ^b (86.00) n = 8	< 15.00

Values in a row with different superscripts are significantly different ($P < 0.05$).

Discussion

Population characteristics of patients with SEHPSS in the Czech Republic is not very different from other studied populations in different countries. It is mostly represented by small dog breeds and by young dogs with lower body weight (Murphy et al. 2001; Hunt 2004; Mehl et al. 2005; Greenhalgh et al. 2010; Falls et al. 2013; Traverson et al. 2018).

In our study population, no death related to SEHPSS was recorded either in the perioperative or in the short-term postoperative periods. The same results were reported by Hunt et al. (2014). Consistently with our study, zero mortality after the surgical treatment of SEHPSS using an ameroid constrictor was described by Bright et al. (2006), who used the ameroid constrictor for surgical treatment of intrahepatic PSS in nine dogs and one cat. In other studies, the mortality rate after the surgical treatment of SEHPSS using an ameroid constrictor ranges from 0 to 7.30% (Murphy et al. 2001; Mehl et al. 2005; Falls et al. 2013; Hunt et al. 2014; Traverson et al. 2018). Patient mortality can be affected by the PSS type, surgeon's experience, but also by the technique used for the surgical treatment of PSS (Burton and White 2001; Greenhalgh et al. 2010; Falls et al. 2013; Hunt et al. 2014). The surgical treatment of PSS using an ameroid constrictor is a quick

and simple technique with minimal perioperative complications (when complying with a careful dissection of surrounding tissue) and with no need to measure the portal pressure during the surgery, thus shortening its duration (Murphy et al. 2001; Mehl et al. 2005; Bright et al. 2006; Falls et al. 2013).

The patients' long-term clinical outcome after the surgical treatment of SEHPSS is the most important aspect of the treatment's success rate, not only from the clinician's point of view, but most importantly, from the owner's point of view. We determined an excellent long-term clinical outcome in 75.00% of patients, a good long-term clinical outcome in 15.00% of patients and a poor long-term clinical outcome in 10.00% of patients in our study. Our study results are similar to those of Mehl et al. (2005) who reported the long-term clinical outcome to be excellent in 80.00%, good in 14.00% and poor in 6.00% of patients in their study. Also Falls et al. (2013) stated an excellent outcome in 75.00% of patients, a good outcome in 17.00% of patients and a poor outcome in 8.00% of patients in their study. These results differ from the study of Traverson et al. (2018), who found an excellent long-term clinical outcome in 45.0% and 39.1% and good long-term clinical outcome in 55.0% and 60.9% of dogs after an ameroid ring constrictor placement and a cellophane banding, respectively. The problem with patient classification is the food they are fed. Feeding PSS patients with a suitable hepatic diet may decrease the amount of toxic metabolic substances that need to be detoxified in the liver, which can temper the clinical signs in these patients. Some owners continue to feed their dog the hepatic diet longer than a few months after the surgical treatment of SEHPSS despite the clinicians' recommendations, either because of the owner's or the patient's preference, but not for medical reasons. This may be the only reason for which the dog cannot be classified as a patient with an excellent long-term clinical outcome according to Mehl et al. (2005). Such patients are not presenting any clinical signs of the disease, but we cannot exclude their recurrence after a switch from the hepatic diet to the regular commercial diet. This situation was observed in two patients in our study and the same problem was also reported by Traverson et al. (2018). Nevertheless, we can state that the surgical treatment of SEHPSS using an ameroid constrictor is a method providing most patients with a favourable short-term and long-term postoperative prognosis.

The analysis of BA and ammonia concentration in patients with SEHPSS is one of the steps in diagnosing the disease. Preprandial BA concentration was elevated in 96.00% of patients and postprandial BA concentration was elevated in 100.00% of patients in our study. Similar values in preoperative BA stimulation test measurements were determined in a study by Bristow et al. (2017), where the preprandial BA concentration was elevated in 98%, and the postprandial BA concentration was elevated in 100% of patients with SEHPSS. Mehl et al. (2005) also observed elevated preprandial BA concentrations in 95% of patients and elevated postprandial BA concentrations in 98% of patients in their study prior to a surgical treatment of SEHPSS. Gerritzen-Bruning et al. (2006) consider BA concentration measurements to be relatively nonspecific; however, in their study they only measured the fasting serum BA concentration. A single fasting sample of BA may not be sufficient for diagnosing PSS, whereas BA stimulation test can be crucial for confirming the diagnosis (Bridger et al. 2008; Bristow et al. 2017). We achieved the same results in our study, where the plasma postprandial BA concentration was elevated in all 25 patients (100.00%), while the plasma ammonia concentration was elevated in only 17 of 21 (80.95%) patients. Similar results were observed in the study by Ruland et al. (2010), who found elevated ammonia concentration in 85.00% of their patients with PSS. On the other hand, Gerritzen-Bruning et al. (2006) reported increased plasma ammonia concentration in 98.04% of patients with PSS. In our study population, conducting BA stimulation test proved to be more reliable for detection of SEHPSS population than the plasma ammonia concentration.

A significant decrease in the BA concentration is noticeable in patients with SEHPSS treated surgically in contrast to patients treated medically (Vogt et al. 1996; Watson and Herrtage 1998; Bristow et al. 2017). Watson and Herrtage (1998) did not observe a significant decrease in the BA concentration in patients with PSS treated medically. Based on these results, we can assume a restoration of the liver function in patients treated surgically in contrast to patients treated medically. Our results showed a significant decrease in the preprandial BA concentration in the period of 4–6 weeks after surgery, whereas a significant decrease in the postprandial BA concentration was observed 2–3 days after the surgical treatment of SEHPSS. Different results were described in a study by Vogt et al. (1996) who found a significant decrease in the preprandial BA concentration 60 days after the surgery and a decrease in the postprandial BA concentration 30 days after the surgical treatment of SEHPSS using an ameroid constrictor compared to the preoperative concentrations. In this study, the authors achieved a slight reduction (at the beginning of the study by 50%, later on by up to 25%) of the vessel diameter when placing the ameroid constrictor on the PSS, whereas in our patients we placed the constrictor without an initial occlusion of the vessel. This could have affected the PSS haemodynamics and, alternatively, measured BA concentrations in these patients, too. Bristow et al. (2017) found that the preprandial serum BA concentrations were elevated in 82.40% of patients and postprandial serum BA concentrations were elevated in 98.00% of patients in a short-term follow-up (3 months postoperatively) after a partial or complete SEHPSS ligation. Contrary to our study, patients with SEHPSS in the study by Bristow et al. (2017) were treated with a complete or partial ligation of the PSS. We can assume that in patients with SEHPSS treated with a partial shunt ligation, there was a higher risk of its incomplete closure, which might have been the reason why the BA concentrations did not return to the reference range. Nevertheless, the authors proved a significant decrease in preprandial and postprandial BA concentrations not only in the short-term period but also in the long-term postoperative period (< 18 months after the surgery) compared to the preoperative concentrations (Bristow et al. 2017). Our results show differences in the preprandial and postprandial BA concentrations decreasing after the surgical treatment of SEHPSS – a significant decrease in the preprandial BA concentration was observed later than a decrease in the postprandial concentration in our study. Therefore, to determine the indicators of liver function in patients after surgery, it may not be sufficient to determine the preprandial BA concentration which may differ significantly from the postprandial concentration. Other authors also use determination of the BA concentration for the postoperative evaluation of continued shunting through the PSS, in contrast to determination of the ammonia concentration (Vogt et al. 1996; Bristow et al. 2017). According to our results, there is a significant decrease in the plasma ammonia concentration already in the period of 2–3 days after the surgical treatment of SEHPSS. Neurological signs of the disease usually resolve soon after surgery in most patients, which may correlate with the decrease of the ammonia concentration in their blood stream.

According to Fossum (2007), medical management should be continued postoperatively until the hepatic parenchyma regenerates, which may take 2–3 months after surgery or even more. Our study shows a rapid decrease in the liver function indicators and a resolution of clinical signs in 18 out of 20 patients at the long-term follow-up. Based on these observations, it may be possible to end the medical management sooner than 2 months after the surgery, in case the animal is clinically free of signs of the disease and does not tolerate the prescribed hepatic diet. The significant decrease in liver function indicators (ammonia and BA) in the days after the surgical treatment of SEHPSS shows a rapid liver regeneration and indicates that the restoration of hepatic function can be achieved very soon after the restoration of normal blood supply. However, we assume that animals after the surgical treatment of PSS cannot simply be categorised as “normal”

individuals, with regard to the BA concentrations. Even though the liver function should be slowly improved, the time necessary for recovery can differ in each animal and even with a successful and correctly performed procedure, regardless of the method used, the liver function may not be completely restored in some dogs (Vogt et al. 1996; Bristow et al. 2017). Our results are in agreement with other studies (Mehl et al. 2005; Falls et al. 2013; Traverson et al. 2018) and show that after the surgical treatment of SEHPSS using an ameroid constrictor, the patients are capable of living a life without any clinical signs of the disease even without a medical treatment, despite the elevation in the postoperative BA concentration which often does not correlate with the patient's clinical outcome (Vogt et al. 1996; Murphy et al. 2001; Bright et al. 2006; Bristow et al. 2017). Bristow et al. (2017) recommend that patients with no clinical signs of the disease, no marked elevation in BA, ammonia or other liver function blood indicators, can be considered as stabilised and that slight abnormalities in BA concentrations can be tolerated. The most important indicator of the surgical treatment's outcome for the clinician and for the owner is the improvement of the patient's clinical status and its return to a normal life. Therefore, this should be the main determining indicator of the treatment's success rate. In this study, the surgical treatment of SEHPSS using an ameroid constrictor has proven to be a safe and successful method of treating this type of PSS.

The limitations of our study are its retrospective nature and the small group of patients observed. Due to the retrospective nature of the study, complete data were not available for each dog in the selected periods. The number of dogs was limited compared to other studies (Mehl et al. 2005; Falls et al. 2013; Bristow et al. 2017; Traverson et al. 2018), as other studies were designed to observe patients for a longer time period or a multi-centric study was conducted. Patients in our study were selected after we reviewed the medical records of dogs at a single medical centre and within the timeframe of 4 years only. In the future, we would like to confirm our results by a study of a larger sample size.

Acknowledgements

This work was supported by the funds of institutional research (TA 29; FVL ITA 2019 - TA191011) of the University of Veterinary and Pharmaceutical Sciences Brno.

This study a part of the diploma thesis submitted by MVDr. Nečasová to the University of Veterinary and Pharmaceutical Sciences Brno in fulfilment of her Master's degree in Veterinary Medicine.

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