Title: Outcomes of dogs treated for extrahepatic congenital portosystemic shunts with thin film banding or ameroid ring constrictor.

Short title (Running head): Thin film banding *vs.* ameroid ring constrictor for extrahepatic CPSS.

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Abstract

Objective: To compare the outcomes of dogs treated for single extrahepatic congenital portosystemic shunts (CPSS) by thin film banding (TFB) or placement of an ameroid constrictor (AC) at a single institution.

Study design: Retrospective case series.

Animals: 76 client owned dogs with CPSS treated with TFB (n=53) or AC (n=23).

Methods: Records were reviewed for signalment, pre-, intra- and postoperative management and short-term outcomes. Data on second surgeries were reviewed. Long-term outcomes were obtained by use of an owner-directed health related quality of life questionnaire. The rates of complications, mortality, and revision surgery were compared between the treatment groups.

Results: Postoperative complications occurred in 15 dogs with TFB (28%) (9% mortality, n=5) and 8 with AC (35%) (4% mortality, n=1) dogs. Long-term follow up was available in 41/56 dogs at a median of 53 (15-88) months. Revision surgery for persistent shunting was performed in 14 (29%) dogs treated initially with TFB, and no dogs treated initially with AC (P=0.007). Median long-term outcome scores were good in both groups. 9/14 revision surgeries led to favorable outcomes.

Conclusions: Persistent shunting requiring revision surgery was more common when CPSS were treated with TFB than AC but both treatments achieved favorable long-term outcomes.

Clinical significance: Treatment of CPPS by placement of an AC rather than a TFB seems more reliable for shunt attenuation and prevention of revision surgeries.

Introduction

Surgery is currently accepted as the preferred treatment for single extrahepatic congenital portosystemic shunts (CPSS) in dogs. [1,2] Acute complete ligation of the shunting vessel is not tolerated in as many as 84% of animals.[3] In order to limit the development of life-threatening portal hypertension and allow complete closure of the shunt without the need for a repeat surgery, several methods for gradual attenuation have been described. The most commonly used techniques for extrahepatic CPSS attenuation are the application of an ameroid constrictor (AC) or a thin film band (TFB), with variable results reported. [4-9] It is hypothesized that TFB incites an inflammatory reaction and fibrosis of the vessel it is placed around, resulting in complete occlusion of the CPSS in 63-65% of dogs. [6,9] However, the stark variations in chemical and ultrastructural composition of the TFB used in practice in addition to the lack of standardization of the TFB placement have raised concerns over the repeatability and reliability of TFB use for shunt attenuation.[10] The casein ring of the AC expands to some degree after implantation, resulting in luminal compression of the vessel along with initiating inflammation and thrombosis, eventually causing vessel occlusion. [11-14] It was demonstrated by recent studies that AC closure mechanism was likely involving calcium-mediated inter-protein interactions rather than the imbibition of water only.[15,16] Complete shunt occlusion is achieved in 79-82% of dogs with this technique. [5,17] Persistence and recurrence of clinical signs is the most common complication of CPSS surgery and is reportedly due to incomplete vessel occlusion with persistent residual shunting (TFB – 16-47%, AC – 18-21%), suboptimal placement of the attenuating device (TFB – 15-40%) or development of additional acquired shunts (TFB – 19%, AC – 4%). [5,6,9,18-20] The evidence directly comparing these techniques is currently limited and assessments of recovery to a ‘normal’ quality of life are lacking.[2] In a recent multi-institutional study it was concluded that the AC provided more predictable vessel occlusion than the TFB based on abdominal ultrasound and a previously established clinical outcome grading score. [4,19] In the attempt to better assess long-term recovery after CPSS surgery, the development of a health-related outcome scoring system (CPSS score) alongside owner-assessed quality of life are described in a recent publication where dogs after CPSS surgery are compared to a healthy control population. [21] It was demonstrated in that study that there are discrepancies between quality of life assessed by the owner and CPSS scores. A significant difference was demonstrated between the CPSS score of normal dogs and of dogs after CPSS surgery. [21]

The objective of this study was to compare the outcomes of dogs treated for single extrahepatic congenital portosystemic shunts (CPSS) by thin film banding (TFB) or placement of an ameroid constrictor (AC) at a single institution. The main aim was specifically to more accurately evaluate the long-term response to surgery by using a recently published health related quality of life score and to report the frequency, reasons for and outcomes of revision surgeries. [21]

Materials and methods

Study population

This study was approved by the University of Bristol Animal Welfare and Ethical review Body (AWERB) (VIN/16/046) and the University of Bristol Research Ethics Committee (FREC).

Descriptive data were gathered solely from the medical records of dogs that underwent diagnosis of and surgical treatment for extrahepatic CPSS from 2009 to 2016 at the Bristol Veterinary School Small Animal Hospital. Long-term follow up was obtained via owner questionnaire, as detailed below.

Medical records review

Records were reviewed for signalment, method of CPSS diagnosis, results of pre-operative serum fasting and postprandial bile acid concentrations, pre-operative medical management, shunt morphology, type of surgery performed, use of portovenography and / or portal pressure measurement, additional surgical procedures performed, duration of surgery, postoperative complications, duration of hospitalization, clinical outcome and requirement for a second surgical intervention. The subjective response to medical management pre-surgery was graded as follows: good = resolution of clinical signs, moderate = improvement in clinical signs, poor = no improvement in clinical signs or relapse.[22] Intraoperative complications were defined as an adverse surgical event that required surgical or therapeutic (pharmacological) intervention to correct. Postoperative complications were defined as an adverse event occurring before hospital discharge.[22] Postoperative mortality was defined as death or euthanasia within 30 days of surgery. Dogs in which partial or complete suture ligation of the CPSS was performed and those with intrahepatic CPSS were excluded.

Follow up

Short-term (< 6 months) outcome information was recorded from the animal’s medical record as per conversations with the referring veterinarian and/or the owner or from re-examination notes. Where available, postoperative serum fasting and postprandial bile acid concentrations were recorded and values outside the reference range were reported. Outcome was graded as previously described as: excellent = clinically normal dogs that were not receiving any medical treatment for hepatic encephalopathy or a prescription diet, good = clinically normal dogs receiving medical treatment for hepatic encephalopathy and / or a prescription diet, poor = dogs with clinical signs of CPSS or dogs that died or were euthanatized because of CPSS. [4]
For dogs that required repeat surgery the following data were collected: type of primary surgery performed, reasons that influenced the decision to perform revision surgery, type of revision surgery, time from initial to revision surgery and outcome.
Long-term (>12 months) outcome information was obtained by use of an online owner-directed health related quality of life (HRQoL) questionnaire, which has recently been reported, additionally to being graded as above. [21] Owners were contacted to participate via telephone, email or regular mail.

CPSS Score

The frequency and severity of clinical signs were used to calculate a CPSS score as previously described (supplementary material). [21] Frequency of each clinical sign was recorded on a five-point categorical scale as: never, less than once a month, monthly, weekly, daily. Clinical signs were divided into three classes according to severity, with class 1 being multiplied by 3, class 2 by 2 and class 3 by 1. For presence of confirmed urolithiasis or urethral obstruction, an additional 2 points were added. For retarded growth an additional 4 points were added if it was present, 2 if the answer was unsure and 0 for not present. This

CPSS score represents a global, semi-objective, score of the dog's HRQoL. Greater CPSS scores represent a more severely affected dog, with the highest achievable score being 110. In addition, owners were asked to rate their dog's overall subjective quality of life (QoL) at the time of last follow up on a visual analog scale from 'Worst imaginable' through to 'Best imaginable'. This gave an owner-perceived QoL score out of 100.

Statistical analysis

Statistical analysis was performed using a statistical software package (SPSS Statistics 24.0.0 IBM, Woking, UK). Data was assessed graphically for normality. Median and range were reported for skewed data. Categorical data were reported as percentages. The complication rate, mortality and the proportion of dogs needing revision surgery were compared between the TFB and AC groups with the Chi-squared or Fisher's Exact tests as appropriate. Significance was set at $P \leq 0.05$.

Results

Study population – Seventy-six dogs met the inclusion criteria. Fifty-three dogs (70%) were treated by thin film band placement and 23 (30%) by placement of an ameroid constrictor. The median age was 14 months (range 4-96 months).

Preoperative data – Diagnosis of an extrahepatic CPSS was made on the basis of clinical signs, hematology, serum biochemistry, bile acid stimulation testing, ammonia and diagnostic imaging. Medical treatment was administered for a median of four weeks (range 1-52 weeks) and consisted of: a combination of a prescription diet, lactulose and antimicrobials in 67 dogs (89%), a combination of lactulose and antimicrobials in six dogs (8%) and solely antimicrobials in one dog (1%). Medical management data were unavailable for one dog and one dog did not receive any medical treatment. Response to medical management was recorded in 67 dogs as good (n=16, 24%), moderate (n=47, 70%) and poor (n=4, 6%). Information on the response to medical management was not recorded in the medical files of seven dogs. Serum bile acid concentrations (SBA) were measured immediately before surgery as follows: fasting SBA in 64 dogs with a median value of 93.2 µmol/L (range 3-387.3µmol/L; reference interval 0-15µmol/L), postprandial SBA in 51 dogs with a median value of 191.4 µmol/L (range 32.8-747µmol/L; reference interval 0-25µmol/L). Pre-operative imaging diagnosis was made by computed tomography angiography (CTA) in 30 dogs and abdominal ultrasound in 45 dogs. Diagnostic imaging was not recorded in the medical file of one dog.

First surgery – The type of surgical treatment was selected at the discretion of the surgeon and was therefore not standardized. Median surgery time was 85 (range 45-150) minutes in the TFB group and 77.5 (range 20-100) minutes in the AC group. Intraoperative portovenography and / or portal manometry were performed at surgeon discretion. Dogs treated with TFB received a partial attenuation to a degree that was considered safe by objective (portal manometry) and / or subjective assessment of portal hypertension intraoperatively. The TFB (Grade MS350, Cello Paper, Fairfield, NSW, Australia) was secured with metallic clips. [18] Additional procedures (cystotomy, ovariectomy, castration) were performed at the discretion of the surgeon and client and were performed in 22 dogs (42%) and 9 dogs (39%) in the TFB and AC group respectively.

Dogs were hospitalized postoperatively for a median of four (range 3-10 days) and five days (range 3-11 days) in the TFB and AC group respectively.

Complications – Complications occurred in 15 dogs (28%) in the TFB group. Intraoperative complications included: intraoperative haemorrhage after laceration of a mesenteric vessel (1), intraoperative hypotension prompting fresh frozen plasma administration (n=1). Immediate postoperative complications included: ascites (n=2), post-operative hemorrhage (n=2) with blood transfusion required (n=1), pancreatitis (n=2) with jugular vein thrombosis (n=1), hypoglycaemia (n=1). Post attenuation neurological signs (PANS) developed in six dogs (seizures (n=5), ataxia/ head pressing that resolved in 48h (n=1)). Seizures leading to death or euthanasia developed in four dogs (8%) two to seven days postoperatively. In the remaining dog who developed postoperative seizures and survived the postoperative period, the seizures were judged to be non-shunt related, as the shunt was attenuated based on CT with concurrent normalization of bile acids. One dog died four weeks postoperatively after an episode of vomiting and dyspnea, despite a good recovery postoperatively. The owner of that dog reported death of one of the littermates following similar signs due to a congenital cardiac problem (suspected by the treating veterinarian). The TFB group had an overall postoperative mortality of 9% (n=5).

In the AC group, complications occurred in eight dogs (35%). One dog developed intraoperative hypotension with subsequent postoperative portal hypertension that prompted revision surgery on the following day to replace the AC with a TFB (Figure 1). Immediate postoperative complications included: anorexia that required placement of a feeding tube (n=2), PANS (generalized seizures, n=3), pancreatitis with ascites (n=1) and persistent regurgitation (n=1). The dog that developed persistent regurgitation was later diagnosed with an oesophageal stricture. One dog in this group (4%) was euthanized due to seizures three days postoperatively. There was no significant difference in postoperative complications (P=0.572) or mortality (P=0.661) between the two groups.

Short-term follow up

TFB group – Short-term follow up was available for 47/49 dogs that survived surgery (including the dog that had been originally treated with an AC but was revised to a TFB the following day, Figure 1). Six dogs (13%) were graded as excellent, 31 (66%) as good and 10 (20%) as poor on follow up. Median time of subjective follow up was three months (range 1-6 months). Postprandial SBA were abnormal in 26/37 (70%) of dogs while only 47% (17/36) of fasted samples were abnormal. Median time of postoperative bile acid testing was 8.5 weeks (range 4-24 weeks).

AC group – Short-term follow up was available for 17/21 dogs that survived surgery (excluding the dog that had their AC removed and replaced with a TFB the following day). One dog (6%) was graded as excellent, 13 (76%) as good and three (18%) as poor on follow up of a median time of two months (range 1-6 months). In this group, postprandial SBA were abnormal in 9/14 (64%) of dogs while 25% (3/12) of fasted samples were abnormal. Median time of postoperative bile acid testing was eight weeks (range 4-16 weeks).

Revision surgery for persistent shunting

Fifteen of 49 dogs (31%) that had a TFB placed were identified to have persistent shunting on diagnostic imaging (CT (n=7), ultrasound (n=6), portovenography (n=2)) in a median time of 5 months (range 2-54 months) postoperatively. Fourteen of these 49 dogs (29%) had revision surgery in a median time of six months (range 3-64 months) after the initial operation (Table 1). One of the 14 dogs (dog 11; Table 1) had two revision surgeries. TFB surgery was revised by placing an AC due to persistent shunting; this surgery was later revised to fully ligate the shunt. Two of the 14 dogs made a good recovery from initial surgery, with normalization of their bile acids. However, they experienced recurrence of clinical signs at 3- and 5-years post-surgery, raising the suspicion of shunt recanalization. None of the dogs that had an AC placed at their initial surgery had a revision surgery performed. There was a statistically significant difference between the rate of revision surgeries performed between the two groups (P=0.007).

Long-term follow up

This information was available for 41/56 dogs (73%) that did not undergo revision surgery (26 TFB and 15 AC) and is presented in Table 2, including mortality. Outcomes of dogs who underwent revision procedures were available for 12/14 dogs (86%) and these are detailed in Table 1. Health-related quality of life questionnaires were returned for 27 dogs. Comparison of subjective owner-perceived quality of life with scores of different outcome grading methods was available for 51% of dogs and is presented in Table 3. Discrepancy between outcome grade, CPSS score and owner-reported quality of life is evident with owners reporting a different quality of life than the CPSS score or outcome grades would indicate.

Discussion

Although a variety of techniques have been reported for the attenuation of extrahepatic CPSS, the evidence base for recommending one treatment over another is weak, with few studies comparing one or more treatments.[2] Although several previous studies have compared AC with suture ligation[23-25], only one has directly compared AC with TFB.[19] We directly compared the short and long-term outcome of AC and TFB using a health related quality of life questionnaire, which has not been used in dogs treated with gradual attenuation devices. We also focused on revision surgeries due to persistent shunting.

We found a high rate of persistent shunting in dogs treated with TFB, with 15/49 surviving dogs (31%) affected and 14 (29%) of these having a revision surgery. This is in agreement with previous studies that report continued shunting / incomplete shunt closure rates of 18-47%. [6,9,19] Persistent shunting can result from failure to completely attenuate the shunt, the development of multiple acquired shunts (MAS), sub-optimal location of attenuation or uncommonly due to failure to identify a second CPSS. [6,20] The marked rate of persistent shunting with TFB may relate to inconsistency of the material used, as well as sterilization and handling methods and potential inconsistency in the amount of compression of the vessel during placement. [7,10,26] The material of the TFB used in our study was consistent throughout the study period and qualified as consistent with cellophane on biochemical and ultrastructural analysis, thereby eliminating the variable of TFB inconsistency. [10] Suboptimal device placement (40% rate reported in one study) may have also been a possible reason for development of persistent shunting in our and other studies. [6,18,19] Inconsistency in reporting procedural details in the patient records may have resulted in missing differences in the level of attenuation provided by TFB placement. We found a much lower rate of persistent shunting in dogs initially treated with AC, with no dogs having revision surgery. One dog, initially treated with a TFB had revision surgery with an ameroid constrictor and subsequently had a further revision surgery due to persistent shunting. On long-term follow up one additional dog in the AC group was euthanatized at an unknown time due to signs attributed to CPSS, potentially increasing the continued shunting rate in the AC group. These findings suggest that the rate of persistent shunting is lower for dogs treated with AC compared with TFB, which agrees with the study by Traverson et al. which documented a persistent shunting rate of 13.6% for TFB and 0% for AC.[19] This is an important finding, as it may influence clinical practice and therefore it is noteworthy that the two studies have reached the same conclusion. The median outcome time in that previous study was 36 months, compared to 55 months in our study.[19] The longer follow-up in our study may have allowed us to identify more long-term persistent shunting associated with TFB compared with the previous report. Long-term persistent shunting was evident in two dogs in our study that had suspected shunt recanalization three- and five years postoperatively. Our low rate of persistent shunting in AC dogs should be interpreted with some caution. Continued shunting rates of up to 24% are reported for AC and subclinical undetected persistent shunting may have been possible in this group in our study. [5] Our sample size for the AC group is considerably smaller than in this previous study, and therefore may be less representative of the population as a whole. The large difference in persistent shunting detected in the TFB group may also have been due to the nature of our study (retrospective, multiple surgeons involved). The nature of the study may further have made it possible that the TFB group was followed up more rigorously (i.e. to have more follow up blood tests or that abnormal blood tests prompted further investigations/ surgery in some dogs more than others), although this is unproven. Additionally, not all dogs were postoperatively evaluated for persistent shunting using a standardized protocol which may have resulted in an underestimation of persistent shunting rates in both groups. With no revisions in the AC group, the likelihood of incorrect attenuation device placement is lower, which suggests that the TFB is not working as effectively as the AC and therefore is failing to completely attenuate the shunt or attenuating it too rapidly and thereby leading to MAS, although MAS was not diagnosed in the dogs that had revisions in the current study. The apparent better predictability of shunt closure with AC compared to TFB in our population also reflects the findings of two studies reporting a much higher material consistency in chemical and ultrastructural analysis of AC compared to TFB. [10,15]

We found the postoperative complication rates for both groups comparable (28% for TFB *vs.* 35% for AC). These rates are higher than those previously reported for these occlusion methods individually (9-13% reported for TFB and 10-20% for AC),[4,5,11,14,18,26] but close to the rates reported in a recent study comparing TFB (26%) and AC (23%). [19] There is inconsistency in the reporting of complication types in past CPSS studies and this could have affected the differences in complication rates. Mortality rates were higher for the TFB group (9% vs. 4% for AC) but overall these were comparable to other studies (0-9% reported for TFB and 0-14% for AC).[4,5,14,17-19,26] Post-attenuation neurological signs were the main cause of mortality in our study as generalized seizures were the cause of death or euthanasia in most dogs (5/6; 83%). This is higher than previously reported in other studies (0-67%), although the rate of mortality related to non-neurological causes (anaesthetic or surgery related) was therefore much lower. [4,8,9,14,18,19,26-28] However, seizures were the only cause of shunt-related mortality in our study.

At long-term follow-up, Dog 7 and Dog 13 (Table 1) were both experiencing intermittent neurological episodes which may have been due to primary portal vein hypoplasia (PVH)/ microvascular dysplasia, and/ or the development of MAS. Portal vein hypoplasia could similarly be responsible for the similar rate of “poor” long-term outcome in both groups, as could the development of MAS or persistent shunting through the original shunt, even though the outcome grade may not be representative of the dog’s true clinical status. While separate hepatic pathology or persistent shunting/ MAS could have been responsible for this high rate, in comparison with previous reports (0-8%) this still remains a high number. [5,19] This may, in part, be related to the retrospective nature of all of the reports and inaccuracy of the outcome grading systems used. The longer median follow up times in our study may have again contributed to this finding.

The baseline clinical outcome grading used in our report is a scheme initially described in a paper by Mehl at al. that was later adapted by several other studies. [4,5,19,29] This grading scheme is imperfect and has the potential to assign individual dogs negative outcomes even though their clinical signs are subjectively mild and rare in occurrence or may even not be directly related to the CPSS. For example, a dog who is free of medical and dietary management but experiences a monthly, or less frequent neurological episode (e.g. head pressing, circling or similar) or an episode of vomiting or lethargy is automatically assigned a 'poor' outcome. The quality of life of such a dog may however be relatively good. Also, short-term grading in our report was obtained at time-points when recommendations for weaning off medication and/ or diet were made. Therefore, a true representation of grades may not have been achieved and interpretation of these outcomes with caution is warranted. For these reasons, a grading scheme has been developed (CPSS score) based on a health-related quality of life questionnaire, in an attempt to refine outcome assessment. [21] That study found that long-term CPSS score remained increased above that of normal dogs, even when owner assessed quality of life was excellent, as demonstrated in our study (Table 3).

Overall, the greater perioperative mortality and higher reoperation rate for the TFB group suggest that, in this cohort, AC achieved a better overall outcome in the short term and seems to be the safer of the two methods, confirming and developing further the results of a recent study. [19] In the current study, revision surgery resulted in ultimate acceptable to excellent short- or long-term outcomes in 8/12 dogs (67%) based on the CPSS score (Table 1). Indeed, it was previously shown that elective staged suture ligation can result in good outcomes for dogs with extrahepatic CPSS. [27,30,31] However, TFB and AC are designed to avoid a second surgery and therefore the high rate of revision in the TFB group is a cause for concern in this cohort. In a recent article six revision surgeries for nine cases of suspected continued shunting after TFB were reported, however clinical outcomes for these dogs were not reported individually. [19] Outcomes for dogs that underwent revision surgeries were reported separately, as those underwent a variety of revision procedures (Table 1).

The study has several limitations related mainly to its retrospective nature. These include a wide variability in follow-up times, reliance on the accuracy and completeness of medical records and owner perceptions and bias, involvement of multiple clinicians in case management and differences in the size of the two populations compared. The persistent shunting rates in both groups should be interpreted with some caution, as not all dogs were routinely screened for successful CPSS attenuation by imaging. Therefore, persistent shunting rates for both groups, could be artificially low. Also, some dogs had more than two surgeries which made grouping difficult.

Although we identified a high rate of persistent shunting in the TFB group we are not able to definitively state whether all of the remaining dogs had complete cessation of shunting. It remains unclear whether the goal of shunt attenuation is to obliterate shunting in all dogs or simply resolve clinical signs and provide the dog with a good quality of life (with some degree of shunting acceptable). It was recently shown that persistent mild increases in pre- and post-prandial bile acids exist despite resolution of clinical signs in dogs treated for extrahepatic CPSS.[32] However, a relatively large proportion of dogs in the TFB group in our study required revision surgery and this would be considered a failure of the initial surgery. The requirement for routine biochemical follow-up and further surgical intervention in dogs with an apparently good outcome but evidence of persistent shunting remains unclear. In our study routine follow-up imaging was uncommon. However, dogs with clinical signs attributable to CPSS and increased serum bile acids had further imaging, which ultimately led to revision surgery due to persistent shunting. Most of these dogs had clinical signs attributable to persistent shunting but a small number were apparently normal, although had markedly abnormal bile acid results.

In conclusion, AC and TFB produced favorable ultimate long-term outcomes based on an owner-directed outcome measure in the reported population of dogs. However, in nearly a third of dogs treated with TFB, revision surgery was required to achieve a favorable outcome, indicating an initial therapeutic failure of the TFB in those dogs. The AC seems to be more reliable in this respect.

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Table 1. Clinical findings, management and outcomes of dogs that underwent revision surgeries, excluding one dog that had their AC revised in the immediate postoperative period. The dog that underwent two repeat surgeries is highlighted. Follow-up grades: excellent – clinically normal dogs not receiving any treatment for CPSS; good – clinically normal dogs receiving a specific diet or medication for CPSS; poor – dogs with clinical signs of CPSS or dogs that died or were euthanatized due to the CPSS (deaths are additionally explained). AC – ameroid constrictor, AUS – abdominal ultrasound, CPSS – congenital portosystemic shunt, CT – computed tomography, HE – hepatic encephalopathy, PPBA – post prandial bile acids, RV referring veterinarian, SBA – serum bile acids.

Dog No.	Primary method of attenuation	Re-presented for	Time following primary surgery (months)	Dg. imaging performed to assess primary attenuation	Indication for revision surgery	Follow-up grade[4]	Method of attenuation at revision surgery	Ultimate outcome – grade[4] (time when obtained in months after most recent surgery)	CPSS score at final follow-up[21,33]	Clinical signs and medical management at long-term follow up
1	TFB	Recurrence of clinical signs (HE) and persistently elevated SBA	5	CT	Persistent shunting	poor	Further partial occlusion of TFB by placing additional vascular clips	excellent (50)	0	Clinically normal
2	TFB	Lethargy, persistently elevated SBA	4	CT	Persistent shunting	good	AC	poor (50)	4	Monthly diarrhea, weekly dysuria (does not appear in discomfort)
3	TFB	Lethargy, persistently elevated SBA	6	CT	Persistent shunting	good	AC	excellent (51)	0	Clinically normal
4	TFB	Behavioral changes, elevated SBA, owner finds difficult medicating	8	CT	Persistent shunting	poor	Full ligation	poor (80)	13	Less than once monthly head pressing, circling, aggression, weakness, diarrhea. Retarded growth.
5	TFB	PU/PD, elevated SBA (were normal on 3m follow up)	64	CT	Shunt re-canalization	good	Full ligation	poor (82)	6	Monthly vomiting. Retarded growth.
6	TFB	Elevated SBA found at RV on pre-sedation bloods for lameness investigation, mild clinical signs (more vocal, restless)	15	AUS	Elevated SBA and clinical signs	excellent	Full ligation	good (2)	N/A	N/A
7	TFB	Collapse episode, vomiting, elevated PPBA	6	Intraoperative portovenography	Recurrent signs of hepatic encephalopathy (no evidence of shunting seen on intraop. portovenography normal intrahepatic portal vasculature, liver also grossly normal)	poor	Full ligation	good (89)	19	Less than once monthly head pressing, disorientation, ataxia, aggression, weakness, vomiting. Monthly circling. Retarded growth. Antibiotics and hepatic diet.
8	TFB	Elevated SBA	3	AUS	persistent shunting	good	Full ligation	excellent (78)	0	Clinically normal
9	TFB	Elevated SBA	3	AUS	Persistent shunting	good	Full ligation	excellent (72)	0	Clinically normal
10	TFB	Elevated SBA	4	AUS	Persistent shunting	good	Full ligation	poor (72)	6	Less than once monthly vomiting and diarrhea, monthly unresponsive episodes.
11	AC	Elevated SBA, urolithiasis, UTI	6	AUS – shunt not confirmed	Urolithiasis	good	Full ligation	good (12)		N/A
11	TFB	Elevated SBA	50	CT	Persistent shunting	good	AC	good (6)	N/A	
12	TFB	Elevated SBA	4	CT	Persistent shunting	good	Additional TFB placement	poor – death in hospital 2 days post surgery – possibl portal thrombus.	N/A	-
13	TFB	Elevated SBA	6	CT	Persistent shunting	good	AC	poor – death/euthanasia du to CPSS	54	Weekly circling, daily seizures, head pressing, disorientation, aggression, unresponsive episodes. Antibiotics, lactulose, hepatic diet.
14	TFB	Urolithiasis, elevated SBA	39	Intraoperative portovenography	Elevated SBA (persistent shunting)		Full ligation	excellent (2)	0	Clinically normal

Table 2. Long-term outcomes for dogs treated for extrahepatic congenital portosystemic shunts by thin film banding (TFB) and ameroid constrictor (AC). Dogs that had revision surgery (n=14) were excluded from this table – outcomes for those dogs are reported separately in Table 1. Information was available for 41 dogs.

	TFB (n=26)	AC (n=15)	Total (n=41)
Median time of follow up in months (range)	66.5 (15-88)	48 (26-72)	53 (15-88)
Follow up available for	26/35 (74%)	15/22 (68%)	41
Dogs alive	24 (92%)	14 (93%)	38 (93%)
Dogs dead or euthanized due to CPSS	2 (8%)	0	2 (5%)
Dogs dead or euthanized unrelated to CPSS	0	1 (7%)	1 (2%)
Excellent outcome[4]	16 (62%)	7 (47%)	23 (56%)
Good outcome[4]	0	3 (20%)	3 (7%)
Poor outcome[4]	10 (38%)	5 (33%)	15 (37%)
Median CPSS score (range)[21]	3.5 (0-20)	4 (0-16)	4 (0-20)

Table 3. Outcomes, congenital portosystemic shunt (CPSS) scores and quality of life scores for 27 dogs treated for CPSS by thin film banding and ameroid constrictor. Dogs who had revision surgery are included.

Short term follow up grade[4]	**Long term follow up grade[4]**	**CPSS score[21] / 110**	**Owner reported Quality of life score / 100**
1	**1**	**0**	**99**
2	**1**	**0**	**100**
2	**1**	**0**	**90**
2	**3**	**16**	**96**
2	**1**	**0**	**100**
2	**3**	**3**	**100**
2	**1**	**2**	**96**
2	**1**	**6**	**94**
2	**3**	**16**	**75**
2	**3**	**20**	**100**
n/a	**1**	**4**	**92**
2	**3**	**4**	**70**
3	**3**	**13**	**79**
2	**3**	**6**	**90**
2	**3**	**3**	**100**
1	**1**	**4**	**76**
2	**1**	**0**	**100**
n/a	**1**	**4**	**95**
2	**3**	**19**	**88**
n/a	**1**	**0**	**100**
n/a	**1**	**0**	**100**
2	**2**	**0**	**99**
2	**3**	**11**	**99**
2	**1**	**4**	**100**
2	**1**	**4**	**100**
2	**1**	**0**	**100**
1	**1**	**0**	**100**