Implications of shunt morphology for the surgical management of extrahepatic portosystemic shunts

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Structured abstract

Objectives: To describe the implications of extrahepatic portosystemic shunt morphology for the chosen site of shunt closure in dogs and cats.

Methods: A retrospective review of a consecutive series of dogs and cats managed for congenital extrahepatic portosystemic shunts was used.

Results: In total 54 dogs and 10 cats met the inclusion criteria revealing five distinct shunt types; left gastro-phrenic, right gastro-caval (types Ai, Aii and Aiii), spleno-caval, colo-caval and left gastro-azygos. Without exception, findings of computed tomography angiography and direct gross observations at the time of surgery confirmed four consistent sites of communication between the anomalous shunting vessel and the systemic venous system; the caudal vena cava at the level of the epiploic foramen, the left phrenic vein at the level of the oesophageal hiatus, the azygos vein at the level of the aortic hiatus and the caudal vena cava or iliac vein at the level of the sixth or seventh lumbar vertebrae. The use of intra-operative mesenteric portography was effective in confirming that at the time of surgery all portal tributary vessels were proximal to the point of shunt attenuation.

Conclusions: Findings confirmed that for the common types of extrahepatic portosystemic shunts seen there were only four consistent sites of communication between the shunt and the systemic venous system. This information supports the use of a systematic approach for location and attenuation of shunts in dogs and cats.

Keywords – Small animal surgery, cardiovascular, portosystemic shunts, attenuation

Introduction

Surgical intervention, which results in closure of the shunting vessel, is considered the definitive treatment for dogs and cats suffering from a congenital portosystemic shunt (PSS).[1-3] A number of surgical procedures have been described for closure of congenital PSSs and these can be divided broadly into either open techniques or minimally invasive vascular interventional techniques.[4-6] With both, it is often not safe to induce an acute complete occlusion of the shunt due to the development of a life-threatening portal hypertension.[7] At open surgery, therefore, it is frequently the case that the shunt is only partially closed using either a ligature, an ameroid constrictor, a cellophane band or hydraulic occluder; all of which are placed around the shunt to induce its gradual occlusion during the postoperative period.[8-15] Regardless of the technique used, it is recommended that the site of closure of the shunt should be at its connection with the systemic circulation.[5,16] Should the shunt be attenuated too far from this site of communication there remains the possibility that portal tributary vessels might exist distal to the point of attenuation leading to the persistence of both portal shunting of blood and clinical signs of hepatic encephalopathy.[5,16-18]

Recently, the most common congenital extrahepatic portosystemic shunts (EHPSSs) involving the azygos, left colic, left gastric, right gastric, left phrenic and splenic veins were independently described in detail using computed tomography angiography (CTA), intra-operative mesenteric portovenography (IOMP) and gross anatomical findings.[19-23] These studies concluded that there was consistency of morphology for these five most common shunt types and that with each type, the site of communication between the shunt and the systemic circulation was highly consistent and anatomically well-defined.[19-22] In a further recent study in which a comprehensive literature review of congenital EHPSS morphology was performed, it was concluded that in dogs four consistent shunt types (spleno-caval, left gastro-phrenic, left gastro-azygos and those involving the right gastric vein) were responsible for 94% of shunts reported in the species, whereas, in cats three consistent shunt types (spleno-caval, left gastro-phrenic and left gastro-caval) were responsible for 92% of extrahepatic shunts reported.[24]

Despite descriptions of surgical shunt attenuation of congenital EHPSSs in current surgical textbooks, their descriptions appear variable and somewhat open to personal preference.[5,25-27] To the authors' knowledge, there have been no previous peer-reviewed publications specifically comparing the types of EHPSSs and their sites of surgical closure. The purpose of this study was to describe the anatomy of the communication between the anomalous vessel (shunt) and the systemic vein for the five most common EHPSSs in dogs and cats, and to use this information to make recommendations regarding the preferred site for surgical shunt attenuation for these shunts.

Materials and methods

This retrospective study reviewed dogs and cats seen by the authors between 2009 and 2016 for the investigation and management of congenital PSS. The main inclusion criterion was that all cases must have a congenital extrahepatic PSS, have undergone preoperative CTA, recorded intraoperative mesenteric portography (IOMP) and recorded direct gross observations at the time of surgery.

CTA was performed using a 16 slice multidetector unit (Brightspeed, General Electric Medical Systems, Milwaukee) as described previously.[19,20] Studies were assessed in their native format utilising multi-planar reconstruction and surface shaded volume rendering using proprietary software (GE AW VolumeShare version 7, General Electric Medical Systems). Vascular maps were obtained and post processing was limited to removal of arterial vessels and unnecessary portions of the caudal vena cava (CVC) from the maps. All CTA studies were reviewed by the authors.

IOMP was carried out during surgery by using a mobile image intensification unit obtaining ventrodorsal images of the abdomen.[20,28] Images were obtained following the temporary, full ligation of the shunting vessel (TFL-IOMP). Angiograms were reviewed at the time of surgery and findings were recorded in the surgical report for each case. Angiograms were recorded digitally and were reviewed respectively by the authors.

The gross anatomy of the shunt was recorded in the surgical report for each case. Information included the course of the distended vasculature, any obvious tributary vessels, its site of entrance into the systemic venous system and the site of shunt attenuation.

Shunts were classified according to the criteria described by both Nelson and Nelson and White and Parry.[19-22,29] On the basis of the combined data of CTA, TFL-IOMP and direct gross observations at the time of surgery recommendations regarding the preferred site for surgical shunt attenuation of the five most common EHPSSs in dogs and cats were confirmed.

Results

In total, 54 dogs and 10 cats met the inclusion criteria. Of these 54 dogs, 23 (43%) were found to have a left gastric vein shunt entering the left phrenic vein (left gastro-phrenic shunt), 11 (20%) had a shunt involving the right gastric vein entering the CVC at the level of the epiploic foramen (right gastro-caval shunt types Ai, Aii or Aiii), 9 (17%) had a shunt involving the splenic and left gastric veins entering the CVC at the level of the epiploic foramen (spleno-caval shunt), 6 (11%) had a shunt involving the left colic vein (colo-caval or colo-iliac shunt) and 5 (9%) had a left gastric vein entering the azygos vein (left gastro-azygos shunt).

Of the 10 cats, 6 (60%) were found to have a left gastric vein shunt entering the left phrenic vein (left gastro-phrenic shunt), 3 (30%) had a shunt involving the left colic vein (colo-caval or colo-iliac shunt) and 1 (10%) had a shunt involving the splenic and left gastric veins entering the CVC at the level of the epiploic foramen (spleno-caval shunt).

Without exception, the findings of CTA and gross findings at the time of surgery jointly confirmed that for each of the five most common shunt types involving the azygos, left colic, left gastric, right gastric, left phrenic and splenic veins there was a consistent site of communication between the anomalous shunting vessel and the systemic venous system. For two of these shunt types, the spleno-caval and right gastro-caval, the site of communication was anatomically the same, so that for the five shunt types there were consistently only five sites of communication. These five sites were the pre-hepatic CVC adjacent to the hepatic artery, the left phrenic vein at the level of the oesophageal hiatus, the azygos vein at the level of the aortic hiatus and the CVC or iliac vein at the level of the sixth or seventh lumbar vertebra. Using the site of venous communication as the determining factor, the distribution of the five most commonly recognised shunt types was as follows:

1) Pre-hepatic CVC at the level of the epiploic foramen
    - Spleno-caval (16% of total cases) (Figure 1)
    - Right gastro-caval (17% of total cases) (Figure 2)
        - type Ai (no gastro-splenic vein with the left gastric vein forming the anomalous vessel prior to its entrance into the CVC and with the splenic vein communicating with the portal vein)
        - type Aii (confluence of left gastric vein and splenic veins to form a gastro-splenic vein entering the portal vein, with continuation of the left gastric vein as the anomalous vessel prior to its entrance into CVC)
        - type Aiii (both the left gastric and splenic veins showed no communication with the portal vein; both draining entirely into the anomalous vessel prior to its entrance into CVC)
2) Left phrenic vein at the level of the oesophageal hiatus
    - Left gastro-phrenic (45% of total cases) (Figure 3)
3) Azygos vein at the level of the aortic hiatus
    - Left gastro-azygos (8% of total cases) (Figure 4)
4) Caudal vena cava or iliac vein at the level of the sixth or seventh lumbar vertebra
    - Left colo-caval (11% of total cases) (Figure 5)
    - Left colo-iliac (3% of total cases)

In all cases, TFL-IOMP was performed following the temporary, full ligation of the shunting vessel at the site of it proposed attenuation. Results in all cases confirmed that the shunting vessel had been correctly identified, encircled and temporarily fully closed. In addition, the TFL-IOMP revealed no evidence for continued shunting of blood through possible portal tributary vessels positioned distal (downstream) to the site of shunt closure (Figures 6 and 7). This was further confirmation that the anomalous shunting vessel had been located and encircled at an appropriate site just proximal to its entrance into a systemic vein.

Reviewing the surgical reports, the surgical approach and exposure of the four sites of venous communication between the anomalous vessel and the systemic vein were consistent and were described as follows. In all cases, the peritoneal cavity was opened via a ventral midline coeliotomy and abdominal wall retraction was achieved either manually or by using a self-retaining retractor (Gelpi, paediatric Balfour, or Gossett).

Pre-hepatic CVC at the level of the epiploic foramen (Figure 8)

The epiploic foramen was visualised in a similar manner to that described in a number of current surgical textbooks.[5, 25-27] Briefly, the epiploic foramen was observed by locating and retracting the duodenum in a ventro-lateral direction towards the patient's left side. The mesoduodeum was used as a mesenteric 'dam' to move the mesenteric root structures towards the patient's left side. This allowed visualisation of the right dorsal structures of the abdomen including the pre-hepatic CVC and the epiploic foramen (Figure 8A). With careful retraction of the mesoduodenum, the anomalous vessel (shunt) could be seen entering the pre-hepatic CVC from the left side at the level of the epiploic foramen (Figure 8B). The coeliac artery (leading subsequently to the hepatic artery) forms the ventral border of the epiploic foramen and in some individuals this artery lay adjacent to the shunt requiring its careful dissection before the shunting vessel could be freed and encircled (Figure 8B). In all cases, shunt attenuation was undertaken via the epiploic foramen at the site of communication between the anomalous vessel and the CVC (Figure 8C & D). Visually, this site of attenuation ensured that all portal tributary vessels were proximal (upstream) of the point of shunt closure.

Left phrenic vein at the level of the oesophageal hiatus (Figure 9)

The oesophagus hiatus was visualised by exteriorising the spleen and protecting it with saline-soaked swabs outside the peritoneal cavity. A stay suture of 2-0 polypropylene (Prolene, Ethicon Ltd) was placed into the fundus of the stomach and was used to pull that portion of the stomach in a caudal direction exposing the left lateral lobe of the liver. The left triangular ligament of the liver was transected using Metzenbaum scissors or unipolar electrocautery. Once this ligament was cut, the left lateral lobe of the liver was retracted in a ventro-lateral direction to the patient's right side, thereby exposing the left dorsal aspect of the diaphragm and the oesophageal hiatus. The anomalous, distended branch of the left gastric vein could be seen running towards the oesophageal hiatus before joining with the left phrenic vein (in some cases, clear recognition of these vessels required the opening of the adjacent lesser omentum using blunt dissection (Figure 9A). The anomalous vessel passed ventral and adjacent to the gastro-oesophageal junction. In all cases, shunt attenuation was undertaken at the site of communication between the anomalous vessel and the left phrenic vein (Figure 9B). Similarly, this site of attenuation ensured that visually all portal tributary vessels were proximal (upstream) of the point of shunt closure.

Azygos vein at the level of the aortic hiatus (Figure 10)

The aortic hiatus was visualised in a similar manner to the oesophageal hiatus. The spleen was exteriorised and protected outside the peritoneal cavity using saline-soaked swabs. A stay suture, placed into the fundus of the stomach, was used to pull the stomach in a caudal direction exposing the left lateral lobe of the liver. Transection of the left triangular ligament allowed the left lateral liver lobe to be manipulated in a ventro-lateral direction to the patient's right side, thereby exposing the left dorsal aspect of the diaphragm and the oesophageal hiatus. The left side of the aortic hiatus was visualised dorsal to the left side of the oesophageal hiatus. In most cases, the anomalous, distended branch of the left gastric vein could be seen running adjacent to the gastro-oesophageal junction before disappearing through the aortic hiatus ventral to the aorta. In the majority of cases, the anomalous vessel passed ventral to the cardia while, in the some, it passed dorsal to the gastro-oesophageal junction. In a few cases, the anomalous vessel could only be located by looking to the right side of the gastro-oesophageal junction (via an opening made in the lesser omentum). In these cases, the anomalous vessel passed through the right side of the aortic hiatus just ventral to the aorta. In all cases, shunt attenuation was undertaken at the site just proximal to the vessel's passage through the aortic hiatus ensuring visually that all portal tributary vessels were proximal (upstream) of the point of shunt closure.

Caudal vena cava or iliac (common) vein at the level of the fifth or sixth lumbar vertebra (Figure 11)

Exposure of the descending colon, left colic vein, the CVC and iliac veins at the level of the sixth or seventh lumbar vertebra was achieved via a more caudal ventral midline coeliotomy that extended caudally to the pelvic brim. The spleen was exteriorised and protected outside the peritoneal cavity using saline-soaked swabs. The descending colon was located and also manually exteriorised through the incision. The greater omentum and underlying small bowel were moved in a cranial direction revealing the pre-renal CVC. The enlarged and distended left colic vein was observed in the mesocolon. The vessel passed in a normal caudal direction before making a 180^{o} turn prior to entering the left side of the CVC at the level of the fifth or sixth lumbar vertebra. Alternatively, the left colic vein was observed to make a 180^{o} turn prior to entering left or right common iliac vein at the level of the sixth lumbar vertebra. In all cases, shunt attenuation was undertaken at the site of the anomalous vessel's communication with the systemic vein (CVC or iliac vein) ensuring visually that all portal tributary vessels were proximal (upstream) of the point of shunt closure.

Discussion

In both dogs and cats, the results of this study confirmed that there were four consistent sites where the five most common EHPSS types entered the systemic venous circulation. The finding of five distinct and commonly recognized EHPSSs was consistent with the recent systematic review by White and others.[24] Further, for each of these five common shunt types, the site of communication between the anomalous shunting vessel and the systemic vein were also highly consistent and defined. For two of the shunt types, the spleno-caval EHPSS and right gastro-caval EHPSS, the anatomical site of the communication between the anomalous shunting vessel were same; that is, the region of the epiploic foramen. In a further two of the shunt types, the left gastro-phrenic EHPSS and the left gastro-azygos EHPSS, the anatomical site of the communication between the shunting vessel (left gastric vein) and the systemic vein (the left phrenic vein or the azygos vein, respectively) was very similar; that is, the region of the oesophageal/aortic hiatus. Likewise, in shunts involving the left colic vein, the anatomical site of the communication between the shunting vessel (left colic vein) and the systemic vein (CVC or common iliac veins) was also similar; that is, the region of the confluence of the iliac veins and the CVC at the level of the fifth or sixth lumbar vertebrae. Previous reports of congenital portosystemic shunts involving the left colic vein in dogs and cats have described some variation in the site of communication between the left colic vein and systemic vein; for example, although the most common variant appears to be direct communication between the left colic vein and the CVC, there are also descriptions of the left colic vein communicating with the common or internal iliac veins (left and right) via the cranial rectal vein.[22] Regardless of these variations, the anatomical site of the communication was always similar (the confluence of the internal and common iliac veins and the CVC in the region of the fifth, sixth or seventh lumbar vertebrae), meaning that the surgical approach was the same regardless of the specific variation in communication between the left colic vein and systemic vein.[22]

These findings confirm that in the majority of patients, at the time of surgery, a systematic approach can be used with confidence to locate the appropriate site for shunt attenuation/closure of the anomalous communication between the shunting vessel and the systemic venous system. Such an approach can be used in the knowledge that for the majority of common extrahepatic portosystemic shunt encountered, the site of communication will be found easily regardless of whether the specific shunt type is known at the time of surgery or not. Combining our findings and the descriptions in current surgical textbooks, the following systematic approach can be advocated.[5,25-27]

In all cases, the abdomen is explored via a ventral midline coeliotomy. In the first instance, due to ease and simplicity, the surgeon might choose to look for the presence of an anomalous communication with the pre-hepatic CVC at the level of the epiploic foramen. An absence of a shunt at this site might then lead to an examination of the oesophageal/aortic hiatus. The absence of an enlarged and distended vessel running over or around the gastro-oesophageal junction might then prompt the surgeon to examine the mesocolon for the presence of an enlarged and distended left colic vein. The systematic approach is applicable for use with any of the procedures used to close or partially close (ligature, ameroid constrictor, cellophane band or hydraulic occluder) a shunt at open surgery. In cases that for whatever reason have not undergone diagnostic imaging prior to surgery, a failure to locate a shunt at any of these sites would most likely indicate one of four things; 1) the patient does not have a congenital portosystemic shunt, 2) the patient has an intrahepatic shunt, 3) the patient has an atypical form of EHPSS, or, 4) the patient has multiple acquired portosystemic shunts.

The authors recognize that certain of the more uncommon shunts types were not encountered in this study. For some of these, such as the previously described right gastro-azygos EHPSS, the site of communication with the systemic vein is recognized to be in the same region as one or more of the common shunt types encountered in this current study.[17,23] Typically, for the right gastro-azygos EHPSS, this communication would be with the azygos vein in the region of the oesophageal/aortic hiatus in a similar manner to that seen with the more common left gastro-phrenic and the left gastro-azygos EHPSSs.[17,23] For other shunts types, such as the spleno-renal EHPSS seen occasionally in cats, the site of communication with the systemic vein (in this case a renal vein) will not necessarily be in the same region of one of the five most common EHPSSs shunts types reported in this study.

Two of the four current surgical textbooks describe an alternative trans-omental approach for the localization of the entrance site of EHPSSs into the pre-hepatic CVC.[5,27] They describe the perforation of the ventral leaf of the greater omentum allowing access to the omental bursa. This approach to the location of EHPSSs was first described by Martin and Freeman.[30] If the stomach is subsequently retracted cranially the portal vein and its tributaries may be identified running within the dorsal leaf of the omentum. Abnormal shunting vessels may be identified and, if applicable, traced to their communication site with the pre-hepatic CVC.[5-27] In the current study, this approach to the pre-hepatic CVC and the epiploic foramen was not used or required; all shunts entering the pre-hepatic CVC at the level of the epiploic foramen were located and attenuated using the mesoduodenum as a mesenteric ‘dam’, as described. Further studies will be required if direct comparisons between these two separate approaches to the epiploic foramen are to be made.

Recently, two separate studies have highlighted the risk for continued shunting of portal blood because of improper selection of the site of shunt attenuation.[16,18] In both studies, the surgical errors regarding the attenuation site were only detected in the postoperative follow-up period and required repeat CTA studies for their documentation. Interestingly, both studies chose not to use the imagining modality of IOMP at the time of shunt attenuation. Such a decision is often determined by a number of considerations, which might include factors such as the surgeon’s experience, the surgical facilities, longer intra-operative times, the potential for increased morbidity associated with the procedure and the financial constraints of the owner. Certainly, in normal dogs, it has been concluded that CTA consistently showed more detail of the extrahepatic portal vein and its tributaries when compared with IOMP.[31] More recently, though, a study comparing the findings of IOMP and CTA for the identification of the portal venous system in dogs and cats suffering from a single EHPSS concluded that an IOMP obtained after the temporary, full ligation of the shunt should still be considered an important part of the surgical procedure.[32] The study showed that an IOMP obtained under these circumstances remained important because, unlike CTA, it could be used intra-operatively to confirm that the shunting vessel had been correctly recognized, that there was only one shunting vessel and that the chosen site of closure included all major portal tributary vessels.[32] Despite this, the technique of IOMP is unlikely to visualize, and therefore eliminate the presence of, very small portal tributaries with complete certainty; for example, the presence of short branches from gastric veins entering a gastro-azygos shunt just before the shunt traverses the diaphragm to enter the azygos vein.[17] Further studies are required to investigate what role IOMP has in reducing the incidence of surgical errors regarding the site of shunt attenuation.

A trans-diaphragmatic approach to attenuate porto-azygos shunts has been described recently.[23] This study suggested that such an approach obviated the need for abdominal organ manipulation and eliminated the risk of missing additional contributing portal branches.[23] Although their description was scant, it appears that their surgical approach to the diaphragm and oesophageal hiatus was similar to that described in our current study; both approaches appear to be relatively simple requiring minimal dissection and organ manipulation. Interestingly, despite advocating the trans-diaphragmatic approach as a means of attenuating the shunting vessel as it terminated into the thoracic section of the azygos vein, the authors confirmed that their approach did not allow the azygos vein itself to be visualized in any of dogs that were operated on.[23] It remains unclear whether the use of our more conservative surgical approach for closure of gastro-azygos shunts in combination with IOMP could be used definitively to rule out the presence of portal tributary vessels near the site of entrance of the anomalous vessel into the systemic (azygos) vein. If this were the case, then combining these two procedures might eliminate the need for a trans-diaphragmatic approach for location and closure of this shunt type. Further studies are required to define the role of IOMP in the surgical management of this specific shunt type.

In conclusion, in the dog and cat, there are four consistent sites where the five most common EHPSS types enter the systemic venous circulation. These, and their related and respective shunt types, are 1) pre-hepatic CVC at the level of the epiploic foramen (spleno-caval, type Ai, Aii and Aiii right gastro-caval shunts), 2) left phrenic vein at the level of the oesophageal hiatus (left gastro-phrenic shunts), 3) azygos vein at the level of the aortic hiatus (gastro-azygos shunts) and 4) caudal vena cava or iliac vein at the level of the sixth or seventh lumbar vertebra (left colo-caval and left colo-iliac shunts). This information confirms that a systematic approach to the location and closure site of the shunt may be used at the time of open surgical intervention. In addition, we recommend the use of IOMP obtained after the temporary, full ligation of the shunt to confirm that, at the time of surgery, all major portal tributary vessels are proximal to the point of shunt attenuation thereby reducing the likelihood of persistence of portal shunting of blood in the postoperative period.

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Figure legends

Figure 1. This image shows a surface-shaded volume rendered computed tomography angiogram of a 12-month-old male miniature schnauzer with a spleno-caval (left gastro-caval)

shunt entering the pre-hepatic CVC at the level of the epiploic foramen. CVC caudal vena cava, PV portal vein, R right, S shunt

Figure 2. This image shows a surface-shaded volume rendered computed tomography angiogram of a 12-month-old female cairn terrier with a right gastro-caval (type Aiii) shunt entering the pre-hepatic CVC at the level of the epiploic foramen. CVC caudal vena cava, PV portal vein, R right, S shunt

Figure 3. This image shows a surface-shaded volume rendered computed tomography angiogram of a 13-month-old male West Highland white terrier with a left gastro-phrenic shunt entering the left phrenic vein at the level of the oesophageal hiatus. CVC caudal vena cava, L left, PV portal vein, R right, S shunt

Figure 4. This image shows a surface-shaded volume rendered computed tomography angiogram of a 5-year-5-month-old male Border terrier with a left gastro-azygos shunt entering the azygos vein at the level of the aortic hiatus. CVC caudal vena cava, L left, PV portal vein, R right, S shunt

Figure 5. This image shows a surface-shaded volume rendered computed tomography angiogram of a 6-year-old female domestic long hair cat with a left colo-caval shunt entering the CVC (in this case the left segment of the CVC) at the level of the sixth lumbar vertebra. CVC caudal vena cava, L left, L seg CVC let segment of caudal vena cava, R right

Figure 6A. A ventro-dorsal IOMP of a domestic short hair cat with a left gastro-phrenic shunt. CVC caudal vena cava, L left, R right, S shunt

Figure 6B. A ventro-dorsal TFL-IOMP obtained from the same case following the temporary, full ligation of the shunt at its communication with the left phrenic vein. Note, the presence of hepatic portal arborisation with no evidence of continued shunting of portal blood through possible tributary vessels positioned distal to the site of shunt closure.

Figure 7A. A ventro-dorsal IOMP of a pug with a type Ai right gastro-caval shunt. CVC caudal vena cava, L left, R right, S shunt

Figure 7B. A ventro-dorsal TFL-IOMP obtained from the same case following the temporary, full ligation of the shunt at its communication with the pre-hepatic caudal vena cava. Note, the presence of hepatic portal arborisation with no evidence of continued shunting of portal blood through possible tributary vessels positioned distal to the site of shunt closure.

Figure 8A. An intraoperative view of a dog showing the pre-hepatic CVC at the level of the epiploic foramen by using the mesoduodenum as a mesenteric 'dam'. Note, the hepatic artery, which forms the ventral border of the foramen. CVC Caudal vena cava

Figure 8B. An intraoperative view of a dog with a spleno-caval shunt, which has been exposed at the level of the epiploic foramen. Note, the proximity of the hepatic artery to the shunt as it enters the pre-hepatic CVC. CVC Caudal vena cava

Figure 8C. An intraoperative view of a dog with a right gastro-caval (type Aiii) shunt. The shunt has been dissected and encircled with a ligature of 2-0 polypropylene (Prolene, Ethicon Ltd) at the level of its communication with the pre-hepatic CVC.

Figure 8D. An intraoperative view of the same dog as in Fig 8C. The image shows the placement of a cellophane band positioned around the shunt at the level of its communication with the pre-hepatic CVC. The band is held in position with four titanium clips.

Figure 9A. An intraoperative view of a domestic shorthair cat with a left gastro-phrenic shunt. The communication between the shunt and the left phrenic vein is located at the level of the oesophageal hiatus. Note, fine black lines have been drawn to demarcate the margins of the shunt and veins. L Left, Oeso Oesophageal

Figure 9B. An intraoperative view of a Shih Tzu with a left gastro-phrenic shunt. The image shows the placement of a polypropylene ligature and a cellophane band, both positioned around the shunt at the level of its communication with the left phrenic vein. A number of titanium clips holding the band in place can be seen.

Figure 10. An intraoperative view of a Shih Tzu with a left gastro-azygos shunt. The site of attenuation at a level just proximal to the aortic hiatus is shown. Oeso Oesophageal

Figure 11. An intraoperative view of a domestic long hair cat with a left colo-caval shunt exposed within the mesocolon of the descending colon. The site of shunt attenuation at the level of the communication between the shunt and the CVC (in this case, the left segment of the CVC) is shown. CVC Caudal vena cava, L Left, L seg CVC Left segment of the caudal vena cava