Complex extrahepatic portocaval shunt with unusual caval features in a cat: computed tomographic characterisation

A two-year-old, neutered male domestic shorthair cat was evaluated for a history of urate calculi, and neurologic signs. Diagnostic imaging revealed an elongated and tortuous single extrahepatic portosystemic shunt which appeared to receive normal tributaries of the caudal vena cava. Surgical correction of the shunt was carried out using cellophane banding. Eight months following surgery, clinical signs had resolved. Computed tomographic angiography allows thorough, rapid imaging of complex vascular anomalies to aid proper surgical correction. Errors in the formation of the portal vein and caudal vena cava can produce complex anomalies of the abdominal vasculature. Persistence of the embryologic left subcardinal vein is proposed to account for the lesion.

CASE HISTORY

A two-year-old, male neutered domestic shorthair cat presented to the North Carolina State University College of Veterinary Medicine Emergency Service for management of acute urethral obstruction. The cat had previous episodes of urethral obstruction, and was also noted to have depressed mentation, chronic intermittent vomiting and episodes of blank staring. Ammonium biurate crystalluria was detected on a urinalysis 2 weeks prior to presentation. Two days prior to presentation a cystotomy for cystolith removal was carried out, and thrombocytopenia (67 x 10^3/µl) was documented.

The cat’s physical examination was unremarkable. Initial complete blood count indicated a non-regenerative anaemia ([RBC count 4.66 x 10^6; 6.91 to 10.49 x 10^6], [haematocrit 19.2%; 32.8 to 49.8], [reticulocyte count 0.42%; absolute=19,572]) and thrombocytopenia (98 x 10^3/µl; 198 to 434 x 10^3) was documented.

Additional and relevant serum chemistry and urinalysis. 227
For surgery, the cat was placed in dorsal recumbency and a ventral midline incision was made beginning just caudal to the sternum and extending just cranial to the pubis. Inspection of the abdomen revealed the shunt vessel from the portal vein heading inside the mesocolon. A 2-0 strand of silk was placed around the vessel proximal to the insertion of the left renal and phrenicoabdominal vein into the aberrant vessel (Fig 3). A cellophane band (Cello/propylene wrap; ULine) was placed and secured with haemoclips. The sutures of the abdomen, subcutaneous and subcuticular tissue and skin were routine. The cat was discharged after an uneventful recovery from surgery. Telephone contact 8 months postsurgery indicated that clinical signs had resolved completely.

**DISCUSSION**

The embryologic development of the portal vein and caudal vena cava is complex process which has been extensively described (Huntington and McClure 1920, Noden and DeLahunta 1985, Hunt and others 1998, Mathews and others 1999). Three embryologic venous systems form the veins of the abdominal cavity, namely the umbilical, vitelline and caudal cardinal veins. The portal system is formed from the vitelline and umbilical venous systems. The paired vitelline veins establish cranial, middle and caudal anastamoses between each other, which separate the veins into cranial, middle and caudal segments. The middle segments are incorporated in the developing liver tissue to form the hepatic sinusoids. The caudal portion of left vitelline vein and the middle anastomosis leads to the formation of the portal vein.

The majority of the caudal vena cava arises from the contributions of three symmetrically paired components of the caudal cardinal venous system which ultimately form a single asymmetric vessel (Bass and others 2000). These components are the caudal cardinal, subcardinal and supracardinal veins. The caudal vena cava may be subdivided from caudal-cranial into prerenal, renal, prehepatic and hepatic segments based on embryologic origin (Noden and DeLahunta 1985). The prerenal segment is derived from the
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right supracardinal vein, with continuation caudally to the iliac veins formed by the cardinal veins. The renal segment is derived from an anastomosis that develops between the supracardinal and subcardinal veins. The prehepatic segment is derived primarily from the right subcardinal vein. The hepatic segment arises from the proximal portion of the right vitelline vein and the right subcardinal vein.

Selective persistence and degeneration, and formation of anastomoses between the embryologic venous systems are critical for normal formation of the portal vein and caudal vena cava. Abnormal anastomoses during development results in congenital extrahepatic PSS (Broome and others 2004). Extrahepatic shunts represent the majority of cases in the cat, most often as a left gastric-caval anomaly (Payne and others 1990, Birchard and Scherding 1992). Complex and atypical variations are also reported, involving other systemic veins and tributaries of the caudal vena cava (Haue and Mullen 1984, Berger and others 1986, Payne and others 1990, Kyles and others 2002, Tillson and Winkler 2002, Szatmári and Rothuizen 2006). The unusual feature of this anomaly was the large calibre distal portion that paralleled the caudal vena cava and incorporated the smaller calibre left renal and phrenicoabdominal veins.

Huntington and McClure (1920) provide a detailed description of caval and renal vein development in the cat. The permanent renal veins form from veins that emerge from the kidney and fuse with the renal collar, an anastomosis between the subcardinal and supracardinal veins. The right subcardinal and supracardinal veins provide primary contribution to formation of the cava at this level. The left subcardinal vein typically atrophies as the left renal vein remodels to develop its final form. However, early in this process the developing vessel pattern has an appearance similar to the distal portion of the shunt in this patient. Additionally, the left phrenicoabdominal vein initially emerges from the cranial aspect of the left subcardinal vein, and later remodels to enter the cava.

A model of persistence of the left subcardinal vein explains the unusual caval features of the anomaly in this patient. PSS formation resulting in increased volume of blood flow provides a mechanism for persistence of the vessel. Incorporation of the left testicular vein by the shunt is also suspected given the normal pattern of drainage of this vein into the left renal vein.

Duplication of the renal veins was also noted bilaterally. In the development of the renal veins, a dorsal and ventral pair initially forms for each kidney, and the dorsal vein usually degenerates (Mathews and others 1999). Duplication results from persistence of both dorsal and ventral vessels. Additionally, bifurcation of each vessel may occur during development, resulting in up to four renal veins draining a single kidney if all vessels persist (Huntington and McClure 1920).

Although abdominal ultrasound was useful in identifying the presence of anomalous vessel and portosystemic shunting, its complexity and the alteration of the normal abdominal vascular structures made full characterisation difficult. The relationships of the anomaly and the other abdominal vessels were best illustrated by CT with angiography, which has advantages of rapid image acquisition and the ability to acquire volumetric data for the construction of three dimensional models and angiograms. This information was essential to prevent correction of the PSS at an improper level that would result in the occlusion of tributaries typically drained by the caudal vena cava. The use of multidetector CT in the assessment of canine extrahepatic PSS has been described (Bertolini and others 2006). By comparison, at our institution abdominal scans are made immediately, 30 seconds, and 60 seconds following a single bolus intravenous injection of contrast medium. This protocol decreases contrast medium dose, and in our experience simplifies and shortens the

FIG 2. Three-dimensional reformat computed tomographic images. (A) Ventral view of abdominal venous vasculature. (B) Line diagram representation of vascular anomaly depicted in (A), and relationship to portal and caval tributaries. (C) Dorsal view, lumbar spine and aorta partially removed. VC Caudal vena cava, PV Portal vein, RPhA Right phrenicoabdominal vein, LPhA Left phrenicoabdominal vein, CrMV Cranial mesenteric vein, CdMV Caudal mesenteric vein, MCV Middle colic vein, LCV Left colic vein
procedure, while consistently providing excellent vascular anatomic detail.

Surgical treatment of PSS in cats with cellophane banding has been sparsely described in the literature. One report mentioned a good outcome of cellophane banding in five cats as stated by normalisation of hepatic values (assessed by rectal ammonia tolerance test or serum bile acids measurements) in three out of the five cats 2 months after surgery (Hunt and others 2004). In the present case, due to poor compliance of the owner, follow-up was limited to phone calls. Therefore we do not have information of the hepatic function postoperatively or images of closure of the shunt, although resolution of clinical signs was reported.

This case report illustrates the potential for development of complex vascular anomalies due to errors in the intricate development of the caval and portal venous systems of the abdomen. Proper characterisation of such anomalies is essential for appropriate surgical planning to ensure a positive outcome in affected patients.

Acknowledgements
The authors would like to thank Alice Harvey for the illustrations.

References
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