Full Circle Forum

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MRI Identification and Surgical Removal of a Brain Tumor in a Cat

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"Bilbo" is a 16.5-year-old neutered male domestic shorthair cat presented to Dr. Grace Park and Dr. Tom Marsh at Greenfield Animal Hospital in Fairfield, CT for acute onset of circling to the left. At that same time, Bilbo was unable to see appropriately. According to his owner, Bilbo's personality had changed significantly over the recent past. He no longer jumped up on things, he spent most of his time in the basement (prior to this he hated the basement), he did not like to be held, and he slept in an upright position like a sphinx. Bilbo had stopped all enjoyable behaviors. Bilbo was also reported to be polyphagic and had difficulty getting into the litterbox. Bilbo also has a history of hyperthyroidism which is successfully managed with oral methimazole. Bloodwork, including thyroid levels, performed by Dr. Park prior to presentation to VCA Shoreline Veterinary Referral and Emergency Center was unremarkable and Bilbo was also normotensive when examined by Dr. Park. Dr. Park and Dr. Marsh referred Bilbo to VCA Shoreline Veterinary Referral and Emergency Center for a neurological evaluation with Dr. Galano.

On presentation to VCA Shoreline, Bilbo had a normal physical examination. However on neurological evaluation, Bilbo was quiet and dull with inappropriate mentation. He was ambulatory and circling to the left. Menace response was absent OD and there was decreased nasal sensation in both nostrils. Postural reactions were normal. Based on these findings, Bilbo neurolocalized to the left forebrain. Differentials included neoplasia, a vascular anomaly, infectious and/or inflammatory disease.

An intracranial work-up was recommended, which included an MRI of the brain and potentially a spinal tap. Prior to general anesthesia for these tests, thoracic radiographs were performed which were unremarkable. The MRI revealed a very large, well-delineated, strongly and homogenously contrast-enhancing mass in the left dorsal aspect of the temporal and occipital lobes of the cerebrum. This mass was extraaxial and had a broad-base of attachment to the overlying skull. There was severe mass effect, evidenced by deviation of the falx cerebri (dura separating the two cerebral hemispheres) to the right and obliteration of the left lateral ventricle. There was hyperostosis of the overlying bone (thickened bone) and a dural tail sign (thickening and enhancement of the dura adjacent to the mass). Based on these MRI characteristics, this mass appeared to be a meningioma, although other differentials including lymphoma, some form of sarcoma, and less likely a glioma, could not be definitively ruled out on the basis of MRI alone. The MRI also revealed a second, very small contrast-enhancing mass more rostral in the cerebrum, adjacent to the falx cerebri in the parietal lobe. This mass also looked like a meningioma, though it was much smaller in size.

"Bilbo" with his owner, Lisa (center) and Dr. Heather Galano (right)

Therapeutic options were discussed with Bilbo's owner. Even though Bilbo was over sixteen years of age, he was a special part of his family. The advantages and disadvantages of conservative therapy versus surgical therapy were reviewed. Surgery for meningiomas in cats is often curative if all of the tumor can

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MRI ID and Surgical Removal of a Brain Tumor *Continued from page 1*

be removed. Radiation therapy may or may not be recommended based on the surgery. Complications of craniectomy and surgical excision include anesthetic complications, intraoperative hemorrhage, worsening of neurological status, and the necessity for ventilatory support post-surgery. If these complications are not encountered, then the prognosis with surgery is very good to excellent. After much discussion and deliberation, Bilbo's owner elected to proceed with surgery.

Surgery was performed using a left rostrotentorial approach to the caudal aspect of the left forebrain. Mannitol and dexamethasone sodium phosphate were given intraoperatively once the dura was excised to expose the tumor. A very large tumor that grossly appeared to be a meningioma was removed. The tumor was grayish-white in color and very easily resectable. Surgery went very well with no intraoperative or anesthetic complications. It appeared that most, if not all, of the tumor was resected. There were no postoperative complications and Bilbo recovered without incident and without the need for mechanical ventilatory support. Bilbo was monitored closely for 24 hours post-surgery in the intensive care unit, with hourly blood pressure checks, temperature checks, mentation checks, PLR checks, respiratory rate and effort checks, and telemetry monitoring. Within 24 hours of surgery, Bilbo was walking in a straight line and no longer circling. He began eating well and was grooming himself and acting very responsive to his surroundings. Bilbo was discharged from the hospital 2 days after the surgery.

Brain tumors occur relatively frequently in cats, with an incidence of about 2.2%. Cats treated conservatively have a guarded to poor prognosis and many die or are euthanized within a few months because of neurological deterioration. Cats treated with more aggressive forms of therapy (surgery, radiation therapy, and/or chemotherapy) live longer with a better quality of life. Aggressive therapy for cats with meningiomas is definitely recommended, as the prognosis is very good to excellent, and very often is curative, independent of the age of the cat. Currently, MRI is the imaging modality of choice for the identification of brain tumors.

Meningiomas are the most common extraaxial brain tumor in cats. They are slow-growing tumors that are considered benign in that they do not tend to metastasize.

Cats that develop meningiomas tend to be older in age and can be of any breed and either sex. Historical and presenting clinical signs are variable and reflect the location, size, and secondary effects of the tumor; however, seizures and behavior changes are the most common presenting signs. With the exception of seizures, the onset of clinical signs is usually slow and progressive due to the slow growth of the tumor. However, if there is decompensation from increased intracranial pressure, signs can develop acutely.

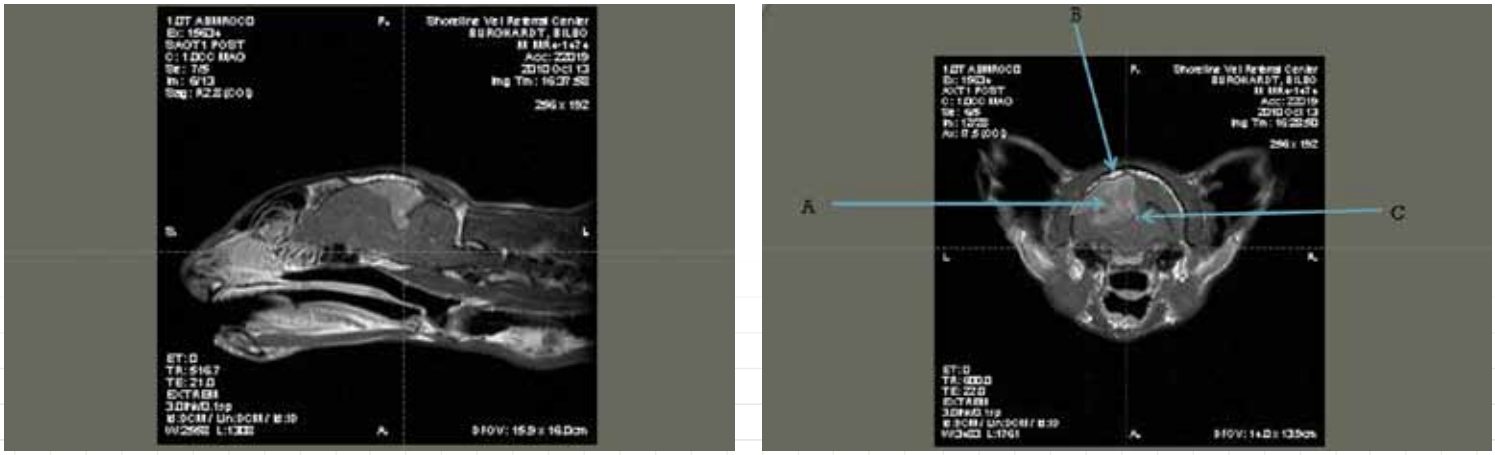
Meningiomas in cats most frequently grow in the forebrain (cerebrum and diencephalons), although they can develop in any part of the brain. Clinical signs associated with forebrain disease include seizures, behavior changes, circling toward the lesion, menace deficit (contralateral), postural reaction deficits (contralateral), head pressing, and hemiinattention.

Diagnostic testing for cats with suspected intracranial disease includes preliminary tests (bloodwork, thoracic radiographs, serum bile acids) and then more advanced imaging with either an MRI or CT scan of the brain.

There are classic MRI findings with meningiomas that allow for reasonable prediction of tumor-type prior to surgery. This is important, as the prognosis for cats with meningiomas is much different than for cats with other types of tumors, especially after surgery and radiation therapy.

The presence of a dural tail sign on MRI is highly suggestive of a meningioma. It indicates an area of contrast-enhancement that extends along the meninges beyond the margins of the mass and may represent neoplasia or inflammatory extension along the meninges. Hyperostosis of the overlying bone is also suggestive of a meningioma. Meningiomas are extraaxial, they have a broad-base of attachment to the meninges, they tend to enhance strongly and homogenously with contrast administration, they are usually well delineated with discrete margins, and they very often cause significant mass effect. Meningiomas may also be cystic in appearance. Meningiomas are usually solitary; however, in cats, there can be multiple meningiomas within one brain, as in Bilbo's case.

Therapy for meningiomas involves either a conservative approach or an aggressive approach. Conservative management involves an anti-inflammatory dose of prednisolone and antiseizure medication (phenobarbital, Keppra) if indicated. The prednisolone is used to decrease intracranial pressure by



***Left**: Sagittal and transverse T1W images post-contrast administration showing an extraaxial strongly and homogeneously contrast-enhancing mass.*
***Right**: Temporal and occipital lobes: (A): Obstruction of the left lateral ventricle. Deviation of falx cerebri to the right. Also note broad base of attachment to overlying meninges; (B):Hyperostosis; (C): Dural tail sign.*

relieving peritumoral edema and decreasing CSF production. The owners must realize that the goal of such therapy is to decrease clinical signs that are due to the secondary effects of the tumor; it has no direct effect on the tumor itself. The tumor will continue to grow despite prednisolone therapy and such therapy is used as a "band aid" for improvement of clinical signs in the short-term (weeks to months). More aggressive therapy involves surgery, radiation, and/or chemotherapy. The advantages of surgery include definitive diagnosis of tumor type, which then allows for accurate prognosis, and debulkment of the tumor, which in turn decreases intracranial pressure. Meningiomas in cats are very amenable to surgery and often times they can be removed in total. Radiation is recommended if gross tumor remains.

The prognosis for cats with meningiomas that undergo surgery and/or radiation therapy is very good to excellent. Surgery is often curative regardless of the age of the cat. If preliminary testing is unremarkable, then surgery is strongly recommended.

Bilbo has done very well since his surgery. At his 2-week post-operative recheck, Bilbo has a normal neurological exam. He has returned to doing behaviors that he has not done in 1-2 years. Bilbo is a very special cat and even at his advanced age, he has benefited tremendously from his craniectomy and tumor removal.

Thank you to Dr. Grace Park and Dr. Thomas Marsh from Greenfield Animal Hospital in Fairfield, CT. Without their prompt referral, Bilbo would not have had the opportunity for surgery and return to an excellent quality of life.

Case report: An Aldosterone-secreting Adrenal Tumor in a Cat

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"Bennie," a 9-year-old MC domestic shorthair was referred to Fifth Avenue Veterinary Specialists on June 16, 2009, for further evaluation of hyperaldosteronism and uncontrolled diabetes mellitus.

The initial work-up and treatment was performed by Dr. Dan Lauridia at Murray Hill Pet Hospital, in Manhattan. Previously in October 2008, Bennie was presented to Murray Hill for general weakness. He was subsequently diagnosed with hypokalemia (2.9 mmol/L), high baseline aldosterone level (2488 pmol/L, reference range 194-388 pmol/L), and persistent hypertension (200-240 mmHg). A full work-up was otherwise normal (including full bloodwork, sodium concentration, thyroid level, urinalysis, and acetylcholine antibody receptor level). An echocardiogram showed mild left ventricular hypertrophy, likely due to systemic hypertension. On abdominal ultrasound, both adrenal glands appeared normal in size and echotexture. Due to the patient's clinical presentation and clinicopathological abnormalities, an aldosterone-secreting adrenal tumor was suspected. However, the normal adrenal gland size precluded surgery, so the patient was managed medically with amlodipine and potassium supplementation at titrated doses. Bennie developed diabetes mellitus in February 2009, and his glucose levels remained uncontrolled despite steady increases in insulin. Shortly afterwards, the patient was referred to FAVS for a recheck abdominal ultrasound.

At this time, a heterogenous and mineralized mass (~2.8x2.8cm) associated with the right adrenal gland was identified. There was no invasion of the vena cava. The left adrenal gland and other abdominal organs were normal. Bennie had a right adrenalectomy

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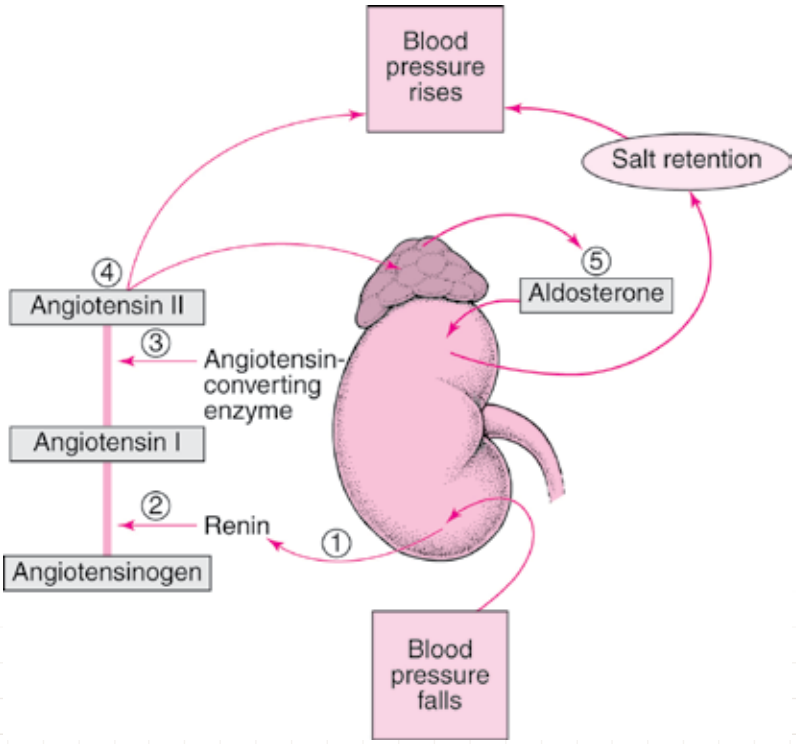

Renin-angiotensin-aldosterone pathway.

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An aldosterone-secreting adrenal tumor in a cat *Continued from page 3*

performed several days later. Biopsies of the liver, pancreas, and omentum were normal. Histopathology of the right adrenal gland showed neoplastic epithelial cells with finely granular cytoplasm, consistent with a benign adenoma although malignancy could not be excluded. Surgical margins were clean. Within one month following surgery, Bennie's diabetes mellitus had resolved, and he was also weaned off amlodipine and potassium supplementation.

Primary hyperaldosteronism (PHA), also called Conn's disease, is an endocrinopathy characterized by excessive autonomous secretion of aldosterone. In cats, it is typically caused by either an adenoma or carcinoma of the adrenal gland. In a retrospective review of 13 cases, seven patients had adrenal adenomas (unilateral or bilateral), while the remaining six had unilateral carcinomas.[1] Other less common etiologies in people include multiple endocrine neoplasia (MEN), familial, and idiopathic. A veterinary case report from 2005 documented MEN in a cat with an aldosterone-secreting adenoma, parathyroid gland adenoma, and pancreatic insulin-secreting tumor.[2] In human medicine, hyperaldosteronism is also associated with insulin resistance and impaired beta-cell function, causing increased risk for development of diabetes mellitus.[3]

Animals diagnosed with PHA are usually older in age; there is no breed or sex predilection.[3] The disease appears more common in cats versus dogs. Patients are typically presented due to side-effects from hypokalemia (weakness, respiratory distress, polyuria, polydipsia) or hypertension (erratic behavior, neurological signs, sudden onset of blindness). The diagnosis is confirmed through measurement of basal aldosterone levels (typically showing a marked elevation, i.e. 5-6 times higher than normal). In people, plasma renin activity should also be concurrently low, although this test is not clinically available in cats at this time. Aldosterone concentrations should be interpreted in combination with the serum potassium level (similar to the insulin:glucose ratio). If the aldosterone concentration is in the high-normal range, but the potassium level is concurrently low, PHA can still be considered as a differential.

After documentation of hyperaldosteronism, abdominal ultrasound is recommended to screen for an adrenal tumor. Failure to find an adrenal mass on ultrasound does not exclude underlying neoplasia, as some adrenal tumors can be small and are not visible until several months after initial diagnosis.[4] Medical therapy consists of supportive care (potassium supplementation and control of hypertension with amlodipine), along with spironolactone, a competitive antagonist of aldosterone in the distal renal tubules. Adrenalectomy is the treatment of choice as hypertension and hypokalemia can be refractory to medical therapy. Aldosterone levels, potassium concentration, and hypertension often normalize shortly after surgery.[1] Post-operative survival in these patients has been documented for up to five years, independent of tumor type.[1]

Dr. Dan Lauridia

"Bennie"

"Bennie's" initial clinical signs and clinicopathologic abnormalities were diagnostic for PHA. However, no adrenal mass was documented at that time, likely due to his early diagnosis in the course of his disease process. On Bennie's recheck abdominal ultrasound, performed nine months later, a right adrenal mass was identified. This progression in adrenal tumor size highlights the importance of repeating imaging at regular intervals, especially if neoplasia is a top concern. "Bennie" had a positive outcome post-surgery, with resolution of his clinicopathologic abnormalities and improvement in quality of life.

In summary, PHA is characterized by concurrent hyperaldosteronism, hypokalemia, and hypertension. PHA should be considered as a differential diagnosis in older cats with unexplained hypokalemia and/or systemic hypertension. If an adrenal mass is identified, surgery is the treatment of choice, and post-operative prognosis is positive.

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Thoracoscopic Lung Lobectomy: An Alternative to Conventional Thoracic Surgery

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"Wutang" is an eleven-year-old, female spayed pitbull mix owned by a referring veterinarian, Dr. Jeremy Sabatini. In the process of working up temporal muscle wasting, a pulmonary mass was found on thoracic radiographs. She was otherwise healthy prior to presentation. Dr. Sabatini brought her to ASC for further work up of and treatment for the muscle wasting and pulmonary mass.

A thoracic and abdominal ultrasound was performed. There was no evidence of a primary tumor in the abdomen. A 4.9 x 3.2cm pulmonary mass was noted in the right cranial thorax. An ultrasound guided aspirate was performed and cytology was consistent with a well differentiated adenocarcinoma.

A CT scan of the thorax was performed to further assess the mass, its location, and to exclude metastasis. The results of the CT scan were consistent with a 5 x 3 x 2cm right cranial lung lobe mass (Figure 1). The tracheobronchial lymph nodes were normal and there was no evidence of metastasis to the other lung lobes. Since the mass was moderate in size and appeared separate from the hilus of the affected lung lobe, a thoracoscopic lung lobectomy was elected.

"Wutang" was prepared for surgery and placed in left lateral recumbancy. Three portals were placed for thoracoscopic surgery. The scope portal was placed at the right ventral seventh intercostal space. Portals were also placed dorsally at the 3rd and 8th intercostal spaces under guidance of the 5 mm 30 degree telescope. A right hemithoracic exploratory was performed. The mass was located at the periphery of the right cranial lung lobe. The remaining lung lobes were normal. A 30mm endoGIA stapler was introduced and guided to the hilus. A complete lung lobectomy was performed. There was no hemorrhage at the stapling site. After the lung was removed, the area around the hilus was re-explored for lymph nodes. The tracheal bronchial lymph nodes were normal in size but pigmented. A lymph node was removed for biopsy. A thoracic catheter was placed and maintained overnight.

"Wutang" recovered uneventfully. A fentanyl constant rate infusion (CRI) and Metacam were used for pain management overnight. She was standing the evening of surgery and comfortable. By the following morning she was walking, eating and very comfortable. The thoracic catheter was negative for fluid or air overnight and thoracic radiographs were normal. The thoracic catheter was removed and the fentanyl CRI was discontinued. Her pain was controlled with a fentanyl patch, Metacam and tramadol and she was released from the hospital that afternoon.

The biopsy results were consistent with a completely resected grade 1 bronchoalveolar adenocarcinoma. The lymph node was normal with dust pigment. The prognosis for this tumor is good. In one study, the median survival was 790 days.[2] It has been 5 months since surgery and "Wutang" continues to do well.

Case Discussion:

Primary lung tumors in dogs are reported to be rare. Metastatic disease to the lung is much more common than primary lung tumors in dogs and cats. Therefore, it is important to appropriately stage these animals prior to surgery with a full physical examination, bloodwork and abdominal ultrasound. CT scan has significantly increased the sensitivity of assessing the lungs for metastasis and aids in the ability to decide if a minimally invasive procedure can be performed to treat a lung lobe tumor or cranial mediastinal mass. A recent article showed that only 9% of pulmonary nodules noted on CT were noted on thoracic radiographs.[1] The same study showed that CT scan detects nodules as small as 1 mm, whereas thoracic radiographs detected nodules larger than 7-9mm.[1] Many hospitals are also using a 16 slice helical CT or better which also significantly decreases anesthesia or sedation time.

The most common pulmonary tumor type is bronchoalveolar adenocarcinoma. The overall median survival for primary lung tumors is one year.[2] Prognosis in dogs is dependent on histologic type, grade, presence of clinical signs, and metastasis to regional lymph nodes. Dogs with low grade tumors with no metastasis or clinical signs had a median survival greater than 790 days.[2] Surgery is recommended as a first line of defense for primary lung tumors. Though most patients with appropriate pain management can be kept quite comfortable after thoracic surgery, many clients are discouraged from surgery despite a potential good prognosis. Over the last 10 years, minimally invasive surgery has become an excellent option to conventional thoracic surgery.

Minimally invasive surgery has significantly improved patient care in veterinary medicine. Minimally invasive surgery increases visualization and decreases post

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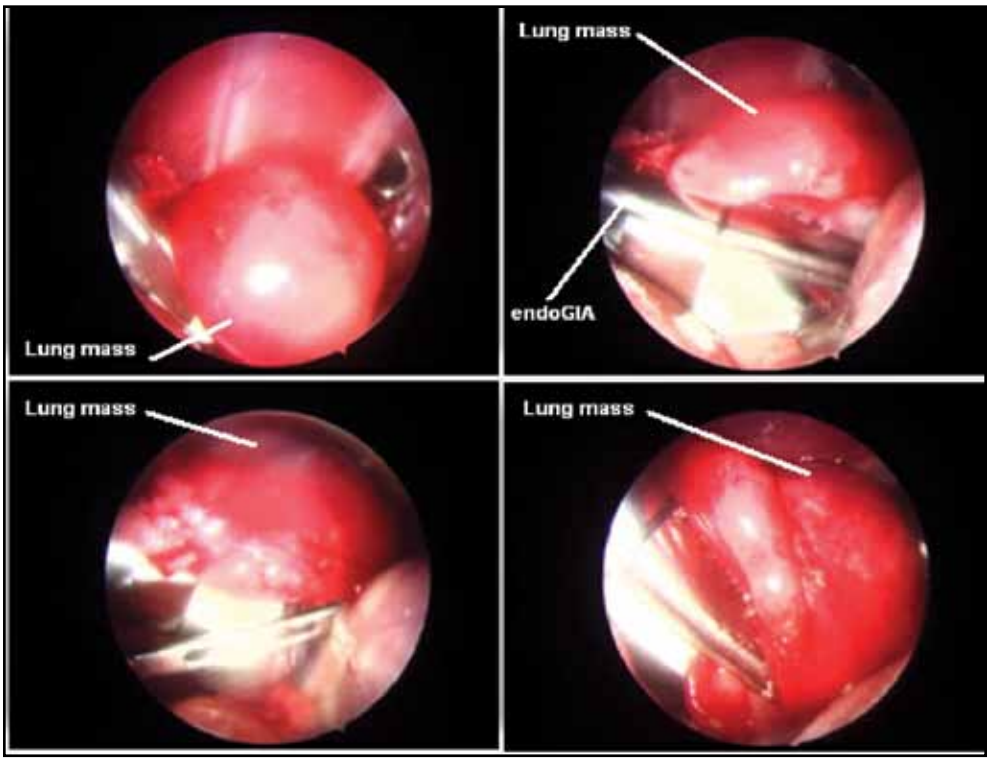
Thoracoscopic Lung Lobectomy *Continued from page 5*



operative pain, incisional complications, and hospitalization time. This has been especially true in thoracic surgery. Lung lobectomies, pericardectomies, thoracic duct ligations, foreign body removal, PRAA transection and small cranial mediastinal mass resections can be performed via thoracoscopy, which eliminates the post-operative pain and complications associated with a sternotomy or thoracotomy. Thoracoscopy can also be used as a diagnostic tool to explore the thorax, aid in surgical planning, and to obtain large biopsies without creating a large uncomfortable incision. Most patients with thoracoscopic procedures can go home the following day, whereas a patient undergoing a sternotomy may need to be hospitalized for 2-3 days. Disadvantages include a steep learning curve and costly equipment. Other minimally invasive procedures that are available include: abdominal exploratory with biopsies, adrenalectomy, cholecystectomy, splenectomy, OHE, feeding tube placement and laparoscopic assisted gastropexy.

In summary, minimally invasive surgery is replacing many procedures previously performed by conventional surgery in veterinary medicine as it becomes standard of care in human medicine. It is important to appropriately stage patients prior to these procedures to avoid frustrations with poor case selection. Perhaps minimally invasive surgery will provide an alternative for owners that are adverse to the post-operative recovery of conventional procedures.

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Congenital Portal-Systemic Shunt in a Yorkshire Terrier

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VCA Veterinary Referral & Emergency Center

"Daisy," a 3-year-old spayed female Yorkshire Terrier, was seen by Dr. Marc Dibernadino at Orange Veterinary Hospital in Orange, CT, for the development of intermittent neurological signs including blindness and loss of balance. This dog had been a patient of Dr. Dibernadino since she was 2 months old and had no prior medical problems. On presentation to Orange Veterinary Hospital, "Daisy" was quiet and only somewhat responsive. She was afebrile and had lost 0.5 lbs since her last routine visit four months prior. On neurological examination "Daisy" was hypermetric in all four limbs, was moderately ataxic and showed dull mentation. "Daisy" was then admitted into the hospital for further workup. Following diagnostic blood and urine collection, "Daisy" was fed a small meal of Hill's A/D on a suspicion of hepatoencephalopathy by Dr. Dibernadino. Shortly thereafter, her neurological status worsened. Upon further questioning of the owners it was determined that all of "Daisy's" abnormal signs seemed to coincide with her mealtimes.

A chemistry panel run on "Daisy's" blood revealed hypoalbuminemia (2.6g/dl), hypocholesterolemia (74mg/dl) and a low creatinine (0.4mg/dl). Urinalysis revealed a low specific gravity (1.011), 3+ blood, negative protein and bacteria (rods). With a high degree of suspicion for a portal-systemic shunt, Dr. Dibernadino also ran pre- and post-prandial bile acid bloodwork.

The pre-sample level was 305.6µmol/L, and the post-sample was 338.7µmol/L (normal <100µmol/L), both very high and consistent with a portal-systemic shunt.

Survey abdominal radiographs were then made at Orange Veterinary Hospital that confirmed a small liver and large kidneys, also consistent with a portal-systemic shunt.

"Daisy" was then placed on Clavamox drops (0.5ml PO BID), lactulose (2.0ml PO TID), Denosyl (90mg PO SID) and small Hill's K/D diet meals fed frequently. Almost immediately "Daisy" improved and became a bright, alert and happy dog with minimal evidence of neurological deficits.

Based on this clinical history "Daisy" was referred to the VCA Veterinary Referral and Emergency Center (VREC) in Norwalk, CT, for further imaging diagnostics. An abdominal ultrasound examination was done using real-time B-mode and color flow and Duplex/Doppler for interrogation of the abdominal vasculature, i.e. portal veins, caudal vena cava, hepatic arteries, splenic veins. This study confirmed that "Daisy" did have a single congenital extrahepatic portal-azygous shunt vessel that was diverting intra-abdominal blood from the spleen, pancreas and GI tract around the liver, into the azygous vein and directly back to the heart. "Daisy" was then admitted to the surgical service at VCA VREC for exploratory laparotomy during which the aberrant shunt vessel was isolated and an ameroid ring constrictor was placed to reduce blood flow through the shunt vessel over time (Fig. 5, next page). "Daisy" was discharged and sent home on Clavamox, tramadol, Denosyl, metronidazole and lactulose. She is doing well.

Portal systemic shunting occurs when anomalous veins allow blood from the portal system to enter the systemic vascular circulation without first passing through the liver. The existence of this anomaly in dogs and cats is a well-recognized source for a variety of sometimes vague clinical signs. Notably, these include: anorexia, vomiting, diarrhea, polyuria/polydipsia, hematuria, stranguria, seizures, mentation changes, obtundation and stunted growth. Portal-systemic shunts can be congenital (most common) and acquired. Congenital shunt vessels develop during gestation and typically manifest as one of three types: single intra-hepatic portal-to-vena cava, single extra-hepatic portal-to-vena cava and single, extra-hepatic portal-to-azygous vein ("Daisy's" shunt, Fig. 2). The first type is commonly found in large breed dogs, i.e. Labrador Retrievers, Boxers, Bernese Mountain Dogs, etc. The second type is commonly found in many small breed dogs, i.e. Chihuahua, Bichon Frise, Lhasa Apso, etc. The third type is typically found in Yorkshire Terriers, Puggles and cats. Acquired shunt vessels, often many in number, occur as a sequela of chronic portal venous hypertension. This hypertension can develop over the life of an animal from diseases such as chronic active hepatitis, cirrhosis and congenital hepatic microvascular dysplasia. Portal hypertension can also spontaneously occur (idiopathic, hepatic infarction). Also, any animal born with a shunt that cannot be completely closed down is subject to the eventual development of portal venous hypertension and secondary acquired shunt vessel formation.

Blood abnormalities associated with shunt pathology include: elevated pre- and post-prandial bile acids (most often >100µmol/L), elevated ammonia levels and, occasionally, elevated hepatic enzymes. Renal values can also rise depending on whether or not concurrent urinary tract infection related to stone formation exists.

There are three important abdominal radiographic abnormalities that are often seen in shunt patients. These are: a small liver (caudal margin, often cranial to 12th thoracic vertebra), plump kidneys (not necessarily long) and renal/cystic calculi (not consistently present). If urinary calculi are seen, they may be formed from ammonium biurate crystals, (products of incomplete liver metabolism of protein), which are often radiographically invisible. At least one (small liver) and, often, two (plump kidneys) of these radiographic abnormalities are found in shunt patients.

Once a strong suspicion for a portal-systemic shunt vessel in a patient is formed, characterizing the location and type of shunt is imperative for successful surgical intervention and for long-term prognosis. Shunt vessel reduction via ameroid ring constrictor (Fig. 5), cellophane banding or ligature placement, if possible, is a key to the success of long-term management of

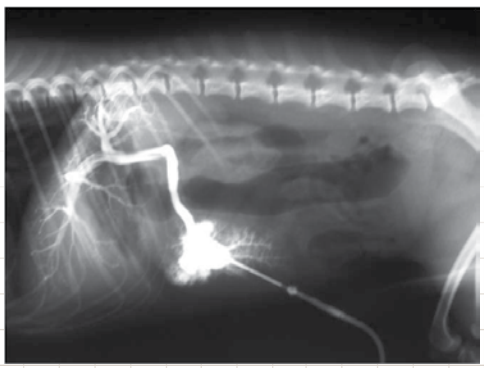

Figure 1

Figure 2

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Congenital Portal-Systemic Shunt *Continued from page 7*

this condition.

Defining the shunt vessel can be done in several ways. In veterinary institutions that have access to nuclear imaging, invasive injection of a radiopharmaceutical into the colon for absorption into the colonic-portal circulation can be done. Radiotracer uptake is then dynamically measured as it flows into the portal circulation and either directly into the liver through an intact portal system or into the systemic circulation and heart via a shunt vessel prior to arriving in the liver. Regions of interest can be computer-evaluated based on intensity/number of radioactive counts coming from the heart and liver; computer time-activity curves can then be generated to confirm shunt blood flow.

Color flow/Duplex Doppler ultrasound evaluation of the portal and intra-abdominal systemic blood vessels can reveal the location, size and flow characteristics (velocity, direction) of single congenital or multiple acquired shunt vessels. Elevated portal vascular velocities, decreased portal vein diameter, increased intra-caval blood flow and turbulence, etc., help to pinpoint an anomalous vessel. However, a significant drawback is operator experience in the successful use of this modality for shunt detection (Fig. 3-4).

Contrast enhanced CT imaging can also be used to confirm portal-systemic shunting. With the newer helical/spiral CT machines (such as the one available at VREC), dynamic arterial and venous-phase contrast enhanced imaging can be done to confirm vascular anomalies. Enhanced 3-D software allows for realistic vascular reconstruction. Often, however, this method of "shunt hunting" is cost-prohibitive when compared to the less expensive, less time-consuming splenoportogram.

Contrast portography has been done for many years to define shunt vessels. Opacifying the portal circulation for shunt discovery requires injecting iodinated contrast material indirectly into the portal venous circulation via the intestinal (mesenterics, jejunal) or splenic venous circulation. Contrast injection (Conray, Renografin, MD76, Iohexol, Iopamidol) into the cranial mesenteric vein or artery for portography has been used for many years. The disadvantage of this procedure is that it requires surgical intervention, often in the radiology suite, for exteriorization and catheterization of these vessels for contrast injection. This makes the entire procedure more time consuming and risky.

Figure 3


Figure 4

Currently, ultrasound guided, intra-splenic venous portography (or… splenoportography) has become the procedure of choice for performing a "shunt hunt." It eliminates the need for a laparotomy by allowing direct organ visualization for manual trans-abdominal catheter placement into either the splenic parenchyma or a splenic vein. Radiographic and/or fluoroscopic images of the injection procedure are then made during opacification of the splenic, portal and systemic venous circulations. Portal blood flow through anomalous vessels into the systemic circulation will 'light up' through this study, allowing for definitive location for surgical repair.

Following induction of general anesthesia in these patients, splenoportography can take as little as ten minutes to complete. The animal is placed in right lateral recumbency on the x-ray table and clipped over the spleen. A survey radiograph can be made to determine proper technique to visualize both the caudal thorax (including the heart) and the cranial abdomen (including the spleen). Once technique is set, a 22 or 20 gauge needle (spinal, injection) attached to extension tubing can be placed with ultrasound guidance into the spleen or a splenic vein (Fig. 1-2, page 7). The opposite end of the extension tubing is connected to a syringe large enough to hold the appropriate amount of contrast material (1ml/lb in ½ total dose injections). Once injection begins (someone must be in the x-ray room to make this injection) the x-ray technician can prep the x-ray machine by starting the anode rotation. When the injector gets down to the last 3-5mls of contrast material, the x-ray exposure can be made during the active injection of these last few ccs of contrast material. The lateral radiographic exposure, if properly set, should show opacification of the splenic vein, portal vein, any shunt vessels and the systemic venous circulation. If the

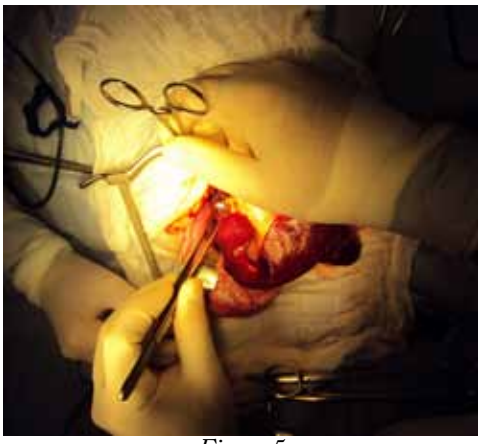
Figure 5

portal vein enters the liver and arborizes appropriately, and if there is no significant simultaneous opacification of the caudal vena cava or azygous vein, no shunt vessel exists (Fig. 1, page 7). The study can then be repeated in the VD position (often with a 45 degree rotation to the left and right), to confirm the shunt's location within the abdomen.

Putting Together an Emergency Crash Cart and Crash Station

Luis Alejandro Lopez, MVZ
VCA Shoreline Veterinary Referral & Emergency Center

A crash cart is a set of trays, drawers, or shelves used during emergencies for the transportation and dispensing of emergency medication and equipment to sites where life support and emergency treatment are provided. A crash cart can be stationary or portable and can be as simple as a small fishing box. If the crash cart is stationary the location is very important. It should be easily accessible, well illuminated, with plenty of electrical access and ideally next to a sink or wet table.

The contents of a crash cart vary between hospitals, but typically they contain the tools and drugs needed to treat a variety of emergency situations such as seizures, shock, or respiratory distress. Supplies for performing an emergency thoracocentesis, pericardiocentesis, or gastric decompression, and for the treatment of acute hemorrhage, cardiac and respiratory arrest should be immediately accessible.

Puppy with respiratory distress at crash station.

Table 1 Common conditions that required immediate attention

Compromised Airway
Respiratory Distress
Respiratory arrest
Cardiac Arrest
Seizures
Hypoglycemia
Shock
Gastric Dilation
Hemorrhage

Suggested Supplies and Drugs for a Basic Crash Cart and Emergency Treatment Area:

For Compromised Airways:

- Assorted sizes of endotracheal tubes
- Oxygen and mask
- Laryngoscope
- Suction devices (tubes, portable suction machine or wall/centralized suction)
- Ambu bag or anesthesia machine for oxygen delivery
- Forceps to retrieve foreign object obstructing airway
- Sedatives or anesthetic drugs such as acepromazine, midazolam, diazepam, propofol, and etomidate
- Diphenhydramine (Benadryl) and corticosteroids such as dexamethasone

Pet Loss Support Meetings

First and third Thursdays of every month, Laurie Sine, LMSW, 7 pm-8:30 pm at Animal Specialty Center, 9 Odell Plaza, Yonkers, NY. Free of charge, open to the public.

Every Tuesday, Irene Javors, 7:30 pm at Fifth Avenue Veterinary Specialists, One West 15th Street, New York, NY. Free of charge, open to the public.

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Emergency Crash Cart and Crash Station *Continued from page 9*

- Tracheostomy kit
- Intravenous catheter kit (assorted catheters, tape, flush, scrub, clippers, t-sets)
- Fluids (crystalloids such as LRS and normal saline)
- Monitors: ECG, blood pressure, capnograph, pulse oximeter

For Respiratory Distress

- Sedatives or anesthetic drugs such as acepromazine, midazolam, diazepam, propofol, and etomidate
- Oxygen and mask
- Intravenous catheter kit
- Monitor: pulse oximeter, ECG
- Drugs that may be indicated in some cases: corticosteroids, bronchodilators (terbutaline), furosemide

For Respiratory Arrest

- Assorted sizes of endotracheal tubes
- Oxygen
- Laryngoscope
- Ambu bag or anesthesia machine
- Suction devices
- Intravenous catheter kit
- Reversal agents such as naloxone and flumezanil
- Fluids
- Monitors: ECG, blood pressure, capnograph, pulse oximeter

For Cardiac Arrest

- Assorted sizes of endotracheal tubes
- Oxygen
- Laryngoscope
- Suction devices
- Ambu bag or anesthesia machine
- Intravenous catheter set kit
- Reversal agents such as naloxone and flumezanil
- Fluids (crystalloids and colloids such as Hetastarch and hypertonic saline)
- Monitors and equipment: ECG, blood pressure, capnograph, pulse oximeter, defibrillator
- Drugs that may be indicated: epinephrine, atropine, vasopressin, dopamine, dobutamine, lidocaine

Seizures

- Oxygen and mask

Organization of emergency butterfly catheters, endotracheal tubes and laryngoscopes in drawer of crash cart.

- Suction devices
- Anticonvulsant drugs such as diazepam and propofol
- Intravenous catheter set kit
- Fluids
- Monitor: blood pressure, glucometer, thermometer, pulse oximeter, ECG
- Drugs that may be indicated: mannitol, corticosteroids, other anticonvulsive medication, dextrose 50%

Injectable medications, syringes, and catheter supplies organized for easy access during emergencies.

For Hypoglycemia

- Intravenous catheter set kit
- Fluids
- Dextrose 50%
- Monitor: blood pressure, thermometer, glucometer
- Drugs that may you need: glucagon

For Shock

- Different sizes of endotracheal tubes
- Oxygen and mask
- Laryngoscope
- Suction devices
- Ambu bag or anesthesia machine
- Intravenous catheter set kit
- Fluid (crystalloids and colloids)
- Monitors and equipment: ECG, blood pressure, capnograph, thermometer, pulse oximeter, defibrillator
- Drugs that may you need: epinephrine, atropine, vasopressin, dopamine, dobutamine, lidocaine, sodium bicarbonate

For Gastric Dilation (Bloat):

- Assorted sizes of endotracheal tubes
- Oxygen
- Laryngoscope
- Suction devices
- Ambu bag or anesthesia machine
- Intravenous catheter set kit
- Gastric lavage tubes (several sizes)
- fluid (crystalloids, colloids or hypertonic saline)
- Monitors and equipment; ECG, blood pressure, capnogram defibrillator
- Drugs that may you need; epinephrine, atropine, vasopressin, dopamine, dobutamine, lidocaine, sodium bicarbonate

Equipment that should be available and ready to use at all times:

- Oxygen administration supplies
- Monitoring equipment such as ECG, blood pressure, defibrillator, pulse oximeter, thermometer
- Venous access such as catheters, t-sets, sterile heparinized flushes
- IV fluids
- Syringe pumps and fluid pumps
- Blood collection tubes
- Laryngoscope
- Suction equipment
- Butterfly catheters and needles
- Extension sets
- Syringes
- Scrub, alcohol, gauze
- Other drugs such as antiarrhythmics
- Other drugs and equipment as chosen by the facility

Crash carts should be tailored to meet the needs of the hospital and species treated. While it is important to have a crash cart that fits the need of your hospital, it is imperative that it is maintained, inventoried, and stocked regularly so that materials, equipment, and medication are

always available. A check list should be developed which includes all inventory, expiration dates of medications (so that they can be replaced as they expire, especially those medications that are not used often). Flushes should be made fresh every week and equipment, monitors, and batteries should be checked weekly. The crash cart should be checked and stocked daily or, certainly, immediately after it has been used. All personnel who may be involved in assisting during an emergency should be fully trained on the use of equipment and monitors, and the importance of maintaining a crash cart and crash station that is ready to use at all times.

Upcoming Events

January 30, 2011 — VCA Shoreline and VCA VREC will present a day of Critical Care Continuing Education for veterinarians and technicians on January 30, 2011 at the Stamford Plaza Hotel, Stamford, CT. Please see page 11 of this issue for program details. Admission is free. Contact Kay Wyler (203) 854-9960 or e-mail kay.wyler@vcahospitals.com or Susan Corona (203) 929-8600 or e-mail susan.corona@vcahospitals.com to register.

February 2–3, 2011 — VCA Shoreline, VCA VREC, Animal Specialty Center, VCA Boston Road Animal Hospital and VCA Cheshire Animal Hospital at the upcoming Connecticut Veterinary Medical Association Annual Meeting at the Mystic Marriott in Groton, CT. VCA Specialists will be available for case consultation and radiography review. Bring any case materials and radiographs you would like to discuss and review. For more information about the meeting and how to register go to www.ctvet.org or email: info@ctvet.org.

February 22, 2011 — Fifth Avenue Veterinary Specialists (FAVS) CE Program. Topics: "What's New in Veterinary Toxicology," Randi Fishkin, DVM, DACVIM, DACVECC; "Canine and Feline Adrenal Disease: Too Much, Too Little, And How to Get It Just Right," Elizabeth Appleman, VMD, DACVIM. Location: Union Square Ballroom, 27 Union Square West, New York, NY 10003, 7:00PM. For further information, contact monica.dunn@vcahospitals.com or (212) 924-3311.

ANNOUNCEMENTS

VCA Shoreline Veterinary Referral & Emergency Center in Shelton, CT, and **VCA Veterinary Referral & Emergency Center** in Norwalk, CT, are excited to announce that Continuous Renal Replacement Therapy (CRRT) will be available at Shoreline beginning January 1, 2011. This service will be run by our Critical Care and Internal Medicine Departments. CRRT is a form of hemodialysis used when gradual toxin removal is indicated in critically ill canines and patients with acute renal failure weighing 20 lbs or more. If you feel that you have a patient that would be a candidate for dialysis or have any questions, please contact Dr. Melissa Holahan or Dr. Danna Torre at VCA Shoreline (203) 929-8600 or Dr. Sam Durkan at VCA VREC (203) 854-9960.

If you would prefer to receive future newsletters via email, please send your request to: fullcircleforum@vcahospitals.com

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