Adrenal Gland Imaging

Ultrasound: In veterinary medicine, ultrasonography (US) has been the imaging modality of choice for evaluation of adrenal masses. This is likely due to its high availability and lower cost as compared to other cross-sectional imaging modalities such as computed tomography (CT) and magnetic resonance imaging (MRI). Although the visualization of vascular invasion is suggestive of malignancy, ultrasonographic features including morphologic characteristics, echogenicity and presence of mineralization cannot always accurately differentiate between benign and malignant adrenal lesions. In general, however, adrenal masses that are larger than 4 cm, exhibit evidence of vascular invasion, and have foci of mineralization are more likely to be malignant.

Computed Tomography: In human medicine, cross-sectional imaging plays a very important role in the identification and characterization of adrenal masses. Morphologic assessment of adrenal masses can aid in the differentiation between benign and malignant etiologies, though there is significant overlap. Benign masses tend to be smooth and relatively homogeneous as compared to the irregular shape and heterogeneous attenuation of malignant adrenal neoplasms. In addition, the attenuation characteristics of an adrenal mass can be measured using CT numbers (in Hounsfield Units or HU). These attenuation values can reflect the composition of the mass, giving clues to its etiology. Benign adrenal lesions in people, such as adrenal adenomas and myelolipomas, typically have high intracytoplasmic lipid content and thus have low attenuation values. In people, an adrenal mass with an average CT number equal to or lower than the threshold of 10 HU is likely to represent a benign neoplasm. Other investigations in people have suggested that adrenal masses with attenuation values greater than 43 HU are compatible with malignancy, even in the absence of vascular invasion, mineralization or hemorrhage.

For undetermined adrenal lesions, such as those with attenuation values between 10 to 43 HU, additional cross-sectional imaging studies are necessary. These include contrast-enhanced CT alone or concurrent with non-enhanced CT, recheck CT examination, as well as chemical shift magnetic resonance imaging (MRI). Contrast-enhanced CT provides an opportunity to evaluate the wash-in and washout characteristics of iodinated contrast. Typically, adenomas enhance rapidly, with a rapid loss of contrast enhancement; malignant lesions show rapid enhancement, but more prolonged contrast washout due to leaky vasculature and retention of contrast. The evaluation of wash-in and wash-out characteristics of contrast enhancement has variable sensitivities and specificities for benign and malignant lesions based on the length of the scan delay period, which is typically 10 or 15 minutes post-contrast administration.

The CT characteristics of normal canine adrenal glands including size, volume, and attenuation have been reported. In veterinary medicine, CT of adrenal masses has been shown
to be valuable as a preoperative indicator of vascular invasion, with a reported sensitivity, specificity and accuracy of 100%, 90% and 95% respectively. In this study, the primary mechanism by which the tumors gained access to the vascular lumen was by way of the phrenicoabdominal veins rather than by erosion of the vascular walls. While all pheochromocytomas in this study showed evidence of vascular invasion, not all tumors exhibiting vascular invasion were malignant. To the author’s knowledge, there have been no studies that have looked at strictly timed assessment of a wash-in/wash-out contrast enhancement protocol for the preoperative characterization of adrenal masses in dogs. Fat content is not a typical feature of canine adrenal adenomas, and to the author’s knowledge the utility of a threshold CT attenuation value has not been established.

Magnetic Resonance Imaging: Magnetic resonance imaging (MRI) offers inherent tissue characterization based on the chemical bonds and environment of hydrogen atoms. While morphologic evaluation and contrast enhancement characteristics provide large amounts of information, the predominant technique in the MR evaluation of adrenal masses is chemical shift imaging.

Some MRI features of normal canine adrenal glands have been reported, although the veterinary literature does not contain many reports of its use in the diagnosis and evaluation of adrenal tumors. In people, the use of in-phase and out-of-phase imaging (or opposed phase imaging) takes advantage of the different resonant frequencies of hydrogen atoms in fat and water, and enables the detection of lipid content in adrenal masses. Owing to the intracellular fat that is present in many of the benign adrenal lesions in people, this technique is helpful in differentiating benign and malignant adrenal masses. However, as stated earlier, fat content is not a typical feature of canine adenomas, and therefore the utility of in-phase and out-of-phase imaging has not been established in the canine patient.

Pancreatic Imaging

Ultrasound: As with adrenal gland imaging, the mainstay of pancreatic imaging in the veterinary patient is ultrasonography. The preponderance of the literature relates to the diagnosis of acute pancreatitis, with an effort to aid in the distinction of acute pancreatitis from acute necrotizing pancreatitis, as well as the presence of abscessation. While color Doppler imaging may be useful in evaluating changes in perfusion, it can be unreliable, and may not yield a clear answer in cases of pancreatic necrosis. Recently, quantitative perfusion analysis of the normal canine pancreas and duodenum has been reported using ultrasonographic contrast agents. However, the utility of contrast-enhanced US in cases of acute necrotizing pancreatitis has yet to be explored.

Commonly, ultrasound is also used to identify pancreatic masses, including neoplastic processes. Presurgical imaging is useful to evaluate surgical resectability and stage disease. The sensitivity of ultrasonography in the detection of canine insulinoma is variable, as ultrasound is significantly operator dependent, and the success of an examination is limited by the size of the patient. Ultrasonography is, however, often helpful in the diagnosis of regional lymphadenopathy and regional metastases to the liver and other surrounding organs. Contrast-
enhanced US has been shown to be effective in the distinction between malignant and benign nodules in the liver and spleen\textsuperscript{38–40}; however, its limited availability and expense have restricted its widespread use in veterinary medicine.

**Computed Tomography:** With the arrival and wide availability of multidetector-row technology, multidetector row computed tomography (MDCT) has become extremely useful in the evaluation of the canine abdomen, including the pancreas.\textsuperscript{37,41–43} In people, CT and MRI considered superior to US for the detection of insulinomas.\textsuperscript{41} Specifically, the utility of dual-phase imaging, or the acquisition of an arterial phase and a portal venous phase of contrast enhancement is valuable in the characterization of normal versus abnormal pancreatic tissue. Dual-phase imaging exploits the alterations in perfusion that are inherent in the vascularity of neoplastic tissue. The propensity toward a significant arterial supply coupled with the leakiness of the poorly formed vessels leads to a greater enhancement on the arterial phase and a delay in the wash-out of positive contrast, as mentioned with the adrenal tumors discussed earlier. This is in contrast to hyperplastic nodules, which tend to have contrast enhancement patterns similar to more normal tissue. In people, a statistically significant difference was noted in the attenuation characteristics of unenhanced studies, the arterial phase, and portal venous phase enhancement patterns between insulinomas and normal pancreatic tissue.\textsuperscript{44} The technique of dual-phase imaging in the diagnosis of canine insulinoma has been described using a single-slice helical CT\textsuperscript{41}; however, at the time of this writing, there are no case series describing the utility of MDCT dual phase imaging and the diagnosis of canine insulinoma.

The use of contrast enhanced single-slice helical CT in the diagnosis of acute necrotizing pancreatitis has been evaluated in 2 dogs in conjunction with US.\textsuperscript{45} While US with color Doppler interrogation was helpful, CT angiography allowed detection of multiple areas of thrombosis that were not identified with US. While imaging is helpful in characterizing pancreatic lesions, it is necessary to sample abnormalities to rule out sepsis in the case of pancreatic necrosis. Image-guided sampling is useful in this regard, and it has been shown that minimal changes occur after image guided fine-needle aspirations of the pancreas are performed.\textsuperscript{46}

**Magnetic Resonance Imaging:** The utility of magnetic resonance imaging (MRI) in the detection of insulinoma in people is widely accepted, however CT seems equally effective in the identification of pancreatic neoplasia. Preoperative CT and/or MRI studies are commonly performed in people with clinically suspected insulinoma, and hypervascular lesions exhibiting delayed wash-out enhancement characteristics are highly suggestive of insulinoma.\textsuperscript{47} Reports of the use of MRI in the diagnosis of pancreatic disease in veterinary medicine are limited.

**Nuclear Medicine:** Somatostatin receptors expressed by insulinomas can be imaged using a specific radiopharmaceutical, $\text{I}^{111}$Pentetreotide (OctreoScan). This has been reported sporadically in the veterinary literature.\textsuperscript{37,48,49} While it may be useful as an adjunct to clinical evaluation of suspected insulinoma, in some cases tumor localization cannot be achieved.\textsuperscript{49}
References