Prevalence of adrenal gland masses as incidental findings during abdominal computed tomography in dogs: 270 cases (2013–2014)

Jared I. Baum BA

Sarah E. Boston DVM, DVSc

J. Brad Case DVM, MS

From the Department of Small Animal Clinical Sciences, College of Veterinary Medicine, University of Florida, Gainesville, FL 32608. Mr. Baum's present address is PO Box 100125 HSC, Gainesville, FL 32610.

Address correspondence to Mr. Baum (baum.jared@ufl.edu).

OBJECTIVE
To determine the prevalence and clinical characteristics of incidental adrenal gland masses identified in dogs undergoing abdominal CT.

DESIGN
Retrospective case series.

ANIMALS
270 client-owned dogs.

PROCEDURES
Medical records of dogs that underwent abdominal CT from June 2013 through June 2014 were reviewed. Patients were excluded if they had undergone CT because of a history or clinical signs of an adrenal gland mass or disease. Information collected included history, signalment, initial complaint, serum alkaline phosphatase activity, urine specific gravity, and whether abdominal ultrasonography was performed. Imaging reports generated by the board-certified radiologist who evaluated the CT images were reviewed.

RESULTS
Incidental adrenal gland masses were detected in 25 of the 270 (9.3%) dogs. Dogs with incidental adrenal gland masses were significantly older (median, 12.0 years; range, 8.0 to 15.0 years) than dogs without (8.2 years; range, 0.1 to 13.1 years). Dogs examined for neoplasia were significantly more likely to have an incidental adrenal gland mass (22/138 [15.9%]) than were dogs examined for any other reason (3/132 [2.3%]), but these dogs were also significantly older. No other risk factors were identified. Histologic examination was performed in only 3 of the 25 dogs with incidental adrenal gland masses; 2 had cortical adenomas and 1 had a pheochromocytoma and cortical adenoma.

CONCLUSIONS AND CLINICAL RELEVANCE
Results suggested that a clinically important percentage of dogs undergoing abdominal CT will have incidental adrenal gland masses, with incidental masses more likely in older than in younger dogs. (*J Am Vet Med Assoc* 2016;249:1165–1169)

In human medicine, incidental adrenal gland masses are defined as adrenal gland masses that are incidentally identified during diagnostic imaging in patients without prior evidence of adrenal gland disease.[1] These masses can be benign (eg, cortical adenomas, granulomas, cysts, or hyperplastic tissue) or malignant (eg, cortical carcinomas, pheochromocytomas, or metastatic masses).[2,3] Incidental adrenal gland masses have also been reported in veterinary patients. A recent report[4] indicated a 4% prevalence of incidental adrenal gland masses in dogs undergoing abdominal ultrasonography. That study found that dogs with an incidental adrenal gland mass were significantly older (median age, 11.25 years; range, 3.5 to 16.9 years) and heavier (median body weight, 21 kg [46.2 lb]; range, 2 to 56 kg [4.4 to 123.2 lb]), compared with the control population (median age, 9.5 years; range, 2 months to 19.2 years; median body weight, 14 kg [30.8 lb]; range, 1 to 71 kg [2.2 to 156.2 lb]).[4]

In human medicine, postmortem diagnosis of incidental adrenal gland masses has been reported in 2.3% of patients,[5] and incidental adrenal gland masses have been identified in 1% to 10% of human patients on the basis of results of CT and magnetic resonance imaging.[6–9] The prevalence of adrenal gland masses increased with age from < 1% in young adults, to 3% at 50 years of age, and up to 15% in patients > 70 years old.[6,10] Another study[11] evaluated the prevalence of incidental adrenal gland masses in routine clinical practice in the Irish adult population. In that study, incidental adrenal gland masses were detected in 0.98% of patients during abdominal CT and in 0.81% of patients during CT of the thorax.

ABBREVIATIONS

ALP	Alkaline phosphatase

Abdominal CT is becoming increasingly common in veterinary medicine. In our practice, we have observed anecdotally that adrenal gland masses are often diagnosed incidentally in dogs undergoing abdominal CT. In human patients, CT has been reported to be a superior modality for the diagnosis of adrenal gland masses, compared with abdominal ultrasonography.[12] Currently, there is no comparable study in veterinary medicine. As such, the purposes of the study reported here were to determine the prevalence of incidental adrenal gland masses in dogs undergoing routine diagnostic abdominal CT, to describe the clinical characteristics of affected dogs, and to evaluate risk factors for the diagnosis of incidental adrenal gland masses in this patient population. We also hoped to evaluate outcome for patients with various types of incidental adrenal gland masses. We hypothesized that the prevalence of incidental adrenal gland masses in dogs undergoing CT would be higher than that previously reported for dogs undergoing abdominal ultrasonography[4] and that incidental adrenal gland masses would be more common in older dogs.

Materials and Methods

Case selection criteria and medical records review

Electronic medical records of dogs that underwent abdominal CT at the University of Florida Veterinary Medical Center between June 2013 and June 2014 were retrospectively reviewed. Information collected included history, signalment, initial complaint, serum ALP activity, urine specific gravity, complete results of abdominal CT, and whether abdominal ultrasonography was performed during the same visit. The diagnostic imaging report that had been generated by the attending board-certified radiologist who evaluated the CT images and had been archived in the medical record was reviewed.

During review of the CT images by the attending radiologist, the size and shape of both adrenal glands were evaluated. Measurements of adrenal gland lesions were made in the dorsoventral and mediolateral dimensions on transverse images and in the craniocaudal dimension on sagittal images. The adrenal gland was considered enlarged if the maximum dorsoventral or mediolateral dimension was > 8 mm. Lesions were further characterized as focal or generalized. If focal changes consistent with a mass were present, the largest dimensions of the mass were obtained. If diffuse changes were present, then the entire adrenal gland was measured.

For dogs in which an incidental adrenal gland mass was identified during CT, additional relevant information was collected from the medical record (eg, results of histologic examination) when available.

Dogs were excluded from the study if they had undergone CT because of a history of an adrenal gland mass or disease or if they had clinical signs consistent with adrenal gland–dependent hyperadrenocorticism or endogenous epinephrine release (eg, hypertension, tachycardia, or collapse).

Statistical analysis

Continuous data were summarized as median and range, and the prevalence of incidental adrenal gland masses was calculated as a simple proportion. Age, body weight, urine specific gravity, and serum ALP activity were compared between dogs with and without an incidental adrenal gland mass by means of a Wilcoxon rank sum test. Age of dogs with versus without neoplasia was also compared with the Wilcoxon rank sum test. The association between presence of an incidental adrenal gland mass and examination for neoplasia was evaluated with a Fisher exact test. A Fisher exact test was also used to test for an association between sex (male vs female) and presence of an incidental adrenal gland mass (yes vs no). A P value < 0.05 was considered significant. A commercial software program was used.[a]

Results

Two hundred seventy dogs met the study inclusion criteria. Of the 270 dogs, 25 (9.3%) had an incidental adrenal gland mass on the basis of results of abdominal CT. Mild adrenal gland enlargement was noted in an additional 9 (3.3%) dogs; however, these cases did not meet the stated criteria for an adrenal gland lesion.

Median body weight for dogs with an incidental adrenal gland mass (28.4 kg [62.5 lb]; range, 4.1 to 46.1 kg [9.0 to 101.4 lb]; n = 25) was not significantly (P = 0.14) different from median body weight for dogs without an incidental adrenal gland mass (21.0 kg [46.2 lb]; range, 0.9 to 75.0 kg [2.0 to 165.0 lb]; n = 245). However, median age of dogs with an incidental adrenal gland mass (12.0 years; range, 8.0 to 15.0 years) was significantly (P < 0.001) greater than median age of dogs without an incidental adrenal mass (8.2 years; range, 0.1 to 16.1 years).

Neoplasia was the initial complaint and subsequent staging was the reason for abdominal CT in 138 of the 270 (51.1%) dogs. Of the 138 dogs examined for neoplasia, 22 (15.9%) had an incidental adrenal gland mass. Dogs examined for neoplasia were significantly (P < 0.001) more likely to have an incidental adrenal gland mass on CT than were dogs examined for any other reason (3/132 [2.3%]); however, these dogs were also significantly (P < 0.001) older. Dogs examined for neoplasia had a median age of 10.0 years (range, 2.0 to 15.6 years), whereas those examined for any other reason had a median age of 5.5 years (range, 0.1 to 16.1 years). Other reasons that patients underwent CT included respiratory, genitourinary, gastrointestinal, cardiovascular (eg, anomalous shunting), or musculoskeletal complaints; vomiting and diarrhea; anorexia and lethargy; trauma; and epistaxis.

Neither serum ALP activity (P = 0.46) nor urine specific gravity (P = 0.93) was predictive of the presence of an incidental adrenal gland mass. Median serum ALP activity of dogs with an incidental adrenal gland mass was 125 U/L (range, 12 to 725 U/L; laboratory reference range, 8 to 114 U/L), compared with median serum ALP activity of 108 U/L (range, 19 to 4,245 U/L) for dogs without an incidental adrenal gland mass. Median urine specific gravity of dogs with an incidental adrenal gland mass was 1.029 (range, 1.014 to 1.053), compared with median urine specific gravity of 1.030 (range, 1.005 to 1.078) in dogs without an incidental adrenal gland mass.

One hundred thirty-two of the 270 (48.9%) dogs underwent both abdominal ultrasonography and abdominal CT. Of these 132 dogs, 4 had an incidental adrenal gland mass identified on ultrasonography but not on subsequent CT, 3 did not have an incidental adrenal gland mass identified on ultrasonography but did have one identified on CT, 6 had an incidental adrenal gland mass identified on both ultrasonography and CT, and 119 had no adrenal mass evident on ultrasonography or CT. Sixteen dogs that had an incidental adrenal gland mass identified on CT did not undergo abdominal ultrasonography.

In the 25 patients with incidental adrenal gland masses, median size was 1.4 cm (range, 0.3 to 6.0 cm) in the maximum dimension. Invasion of the caudal vena cava was noted in 3 of 25 patients. Surgical resection of the mass was performed in 3 dogs, not including the 3 dogs with involvement of the caudal vena cava. Two dogs had a diagnosis of cortical adenoma and 1 dog had 2 different adrenal gland lesions (cortical adenoma and pheochromocytoma) diagnosed in the same adrenal gland on the basis of histologic examination of biopsy samples. Of the 22 dogs without histologic confirmation, 2 dogs were reassessed with ultrasonography (1 after 5 months and 1 after 6 months), and the masses remained unchanged (0.9 cm and 1.4 cm in the maximum dimension, respectively).

Discussion

Results of the present single-center retrospective study conducted over a 1-year period (2013 to 2014) found a 9.3% prevalence of incidental adrenal gland masses in dogs undergoing abdominal CT. Dogs with an incidental adrenal gland mass were significantly older than dogs without one. Dogs examined for neoplasia were significantly more likely to have an incidental adrenal gland mass than were dogs examined for any other reason, but this likely reflected the fact that dogs examined for neoplasia were older. The prevalence of incidental adrenal gland masses identified on abdominal CT in the present study (9.3%) was higher than prevalence reported in a recent study[4] of dogs undergoing ultrasonography (4%). In human patients, CT has been reported to be a superior modality for the diagnosis of adrenal gland masses, compared with abdominal ultrasonography.[12]

Seven dogs in the present study that underwent both abdominal ultrasonography and CT had discrepant results, with 4 dogs having an adrenal gland mass identified on ultrasonography but not on CT and 3 dogs having an adrenal gland mass identified on CT but not ultrasonography. We suggest that this can be explained in part by the relatively low sensitivity and specificity of abdominal ultrasonography, compared with CT, as reported in human medicine. Two studies[12,13] in human patients have reported that CT is the diagnostic imaging modality of choice for detection of adrenal gland masses. One study[13] found that CT had a sensitivity of 84%, a specificity of 98%, and an accuracy of 90%, whereas ultrasonography had a sensitivity of 79%, a specificity of 61%, and an overall accuracy of 70% when imaging patients with suspected adrenal gland disease. It is difficult to explain why 4 dogs in the present study had an adrenal gland mass identified on ultrasonography but not on CT. Nevertheless, the inconsistency between results of CT and abdominal ultrasonography in a small number of dogs suggested that false-negative results were possible with either modality and that if an adrenal gland lesion is suspected, both diagnostic imaging modalities should be considered. Further investigation comparing abdominal ultrasonography and CT for the diagnosis of adrenal gland masses in dogs is suggested.

In the present study, we found that dogs with an incidental adrenal gland mass were older than dogs without. This was consistent not only with results of previous studies of human[5–7,10] and veterinary patients,[4,6–9] but also with our clinical experience. Median reported age of dogs with cortical adrenal gland tumors and pheochromocytomas is between 10 and 11 years,[4,14–18] and we suggest that it is reasonable to consider that older dogs are more likely to have incidental adrenal gland masses. Dogs examined for neoplasia in the present study were also significantly more likely to have an incidental adrenal mass, compared with dogs examined for any other reason. Interestingly, in the recent study by Cook et al[4] that evaluated the prevalence of incidental adrenal gland masses in dogs undergoing abdominal ultrasonography, 28.5% of dogs with an incidental adrenal mass had concurrent neoplastic disease. In the present study, 15.9% (22/138) of dogs examined for neoplasia had an incidental adrenal gland mass. However, we suggest that our data may simply reflect the fact that older dogs are more likely to develop neoplasia. The higher prevalence of adrenal gland masses in dogs examined for neoplasia may also be related to a higher risk for adrenal gland metastases. A previous study[19] found that the frequency of tumor metastasis to the adrenal glands was 21.0% in dogs with metastatic neoplasia. Although a definitive recommendation cannot be made on the basis of results of the present study, we suggest that it may be clinically appropriate to consider thoracic and abdominal CT when staging older patients with neoplasia to rule out both metastatic and occult concurrent disease prior to proceeding with major treatment interventions.

The present study was limited by the fact that a single board-certified radiologist did not retrospectively review all CT images. Although we recognize this limitation, we believe that such a review may have had the potential to introduce bias. The objective of this study was to retrospectively determine the prevalence of incidental adrenal gland masses, and in our hospital, all CT images are evaluated by a board-certified radiologist. The radiologist on duty evaluates each CT scan methodically, but without the specific objective of identifying adrenal gland abnormalities. If a radiologist reevaluated the CT scans with the specific aim of looking for incidental adrenal gland masses, we suggest that it is possible that the number of cases with incidental adrenal gland masses might increase because the radiologist would be specifically evaluating the adrenal glands. As such, we elected to rely on the archived reports in the electronic medical records.

The present study was also limited by the lack of follow-up information and histologic diagnoses for most patients. The larger question after determining the prevalence of incidental adrenal gland masses is to determine the clinical importance and impact on clinical decision making. Currently there are no standard, evidence-based recommendations to guide the diagnostic evaluation and treatment of veterinary patients with incidental adrenal gland masses. In human patients, the recommended approach is dependent on evaluation of CT imaging characteristics. If the mass is > 4 cm in any dimension and there are imaging characteristics consistent with malignancy, such as an irregular border, < 40% washout of contrast medium after 15 minutes, inhomogeneity, or mineralization, then surgical resection is recommended.[20] In patients that do not undergo surgery, there is no consensus on appropriate follow-up evaluation. For masses that appear to be benign, small (< 3 cm), and biologically inactive on the basis of results of laboratory testing, repeated diagnostic imaging and serum biochemical reevaluation analysis after 1 to 2 years are considered appropriate.[20] For more indeterminate lesions, repeated evaluation for growth after 3 to 12 months is recommended.[20] Although it is difficult to translate this information directly to veterinary patients without further study, these guidelines may be the basis for evaluation and treatment recommendations for dogs.

At present in our hospital, recommendations for dogs with an incidental adrenal gland mass depend on the owner's goals, the size of the mass, and the presence of any clinical or laboratory abnormalities. If the mass is > 2 cm in diameter on CT or ultrasonographic images, if there is evidence of vascular invasion, or if the patient has clinical or laboratory signs consistent with an adrenal gland lesion, further diagnostic testing is recommended. This includes evaluation for hypercortisolism and evaluation for clinical signs consistent with pheochromocytoma. Cook et al[4] reported that adrenal gland masses ≥ 20 mm in any dimension indicated malignancy. Two recent studies[17,18] in dogs described the characteristics of malignant adrenal gland lesions identified with CT and contrast-enhanced ultrasonography. In dogs that undergo contrast-enhanced ultrasonography, adrenocortical adenomas may be distinguished from both adrenocortical carcinomas and pheochromocytomas on the basis of the vascular pattern and contrast-enhancement characteristics.[17] Gregori et al[18] evaluated the characteristics of malignancy with CT and reported that the presence of vascular invasion was predictive of pheochromocytomas, with some indications of malignancy dependent on the pattern of contrast distribution.

In a dog with hypertension, polyuria, polydipsia, high ALP activity, or some combination of these clinical and laboratory signs, further diagnostic testing would be suggested even in the presence of a small incidental adrenal gland mass without apparent characteristics of malignancy on abdominal CT. We suggest that such a patient should be screened for adrenal gland–dependent hyperadrenocorticism and that serial blood pressure measurements should be obtained. For a patient with an incidental adrenal gland mass < 2 cm in any dimension with no clinical or laboratory signs of adrenal gland disease, careful monitoring may be a reasonable approach. The addition of baseline abdominal ultrasonography may be desirable for patients with a small mass (ie, < 2 cm) identified on abdominal CT to allow for a less expensive approach to ongoing monitoring that does not require general anesthesia. The adrenal gland mass may be monitored by means of repeated ultrasonography every 2 to 3 months.

Acknowledgments

This manuscript represents a portion of the work completed for the University of Florida Merial Veterinary Scholars Program and completion of VEM 5991: Individualized Investigation at the University of Florida College of Veterinary Medicine.

Presented as a poster at the 15th Annual Merial–National Institutes of Health Veterinary Scholars Symposium, Ithaca, NY, August 2014, and at the American College of Veterinary Surgeons Surgery Summit, Nashville, Tenn, October 2015.

The authors thank Blanca Carbia for technical assistance.

Footnotes

a. JMP, version 9.0.2, SAS Institute Inc, Cary, NC.

References

1. Tabarin A. Adrenal incidentalomas [in French]. *Presse Med* 2014;43:393–400.
2. Fossum TW, Hedlund CS, Johnson AL, et al. Surgery of the endocrine system. In: *Small animal surgery*. 3rd ed. St Louis: Mosby/Elsevier, 2007;578–584.
3. Menegaux F, Chéreau N, Peix J-L, et al. Management of adrenal incidentaloma. *J Visc Surg* 2014;151:355–364.
4. Cook AK, Spaulding KA, Edwards JF. Clinical findings in dogs with incidental adrenal gland lesions determined by ultrasonography: 151 cases (2007–2010). *J Am Vet Med Assoc* 2014;244:1181–1185.
5. Barzon L, Sonino N, Fallo F, et al. Prevalence and natural history of adrenal incidentalomas. *Eur J Endocrinol* 2003;149:273–285.

6. Kloos RT, Gross MD, Francis IR, et al. Incidentally discovered adrenal masses. *Endocr Rev* 1995;16:460–484.
7. Copeland PM. The incidentally discovered adrenal mass. *Ann Intern Med* 1983;98:940–945.
8. Gross MD, Shapiro B. Clinical review: 50 clinically silent adrenal masses. *J Clin Endocrinol Metab* 1993;77:885–888.
9. Ross NS, Aron DC. Hormonal evaluation of the patient with an incidentally discovered adrenal mass. *N Engl J Med* 1990;323:1401–1405.
10. Grumbach MM, Biller BMK, Braunstein GD, et al. Management of the clinically inapparent adrenal mass ("incidentaloma"). *Ann Intern Med* 2003;138:424–429.
11. Davenport C, Liew A, Doherty B, et al. The prevalence of adrenal incidentaloma in routine clinical practice. *Endocrine* 2011;40:80–83.
12. Korobkin M, Francis IR. Adrenal imaging. *Semin Ultrasound CT MR* 1995;16:317–330.
13. Abrams HL, Siegelman SS, Adams DF, et al. Computed tomography versus ultrasound of the adrenal gland: a prospective study. *Radiology* 1982;143:121–128.
14. Anderson CR, Birchard SJ, Powers BE, et al. Surgical treatment of adrenocortical tumors: 21 cases (1990–1996). *J Am Anim Hosp Assoc* 2001;37:93–97.
15. Herrera MA, Mehl ML, Kass PH, et al. Predictive factors and the effect of phenoxybenzamine on outcome in dogs undergoing adrenalectomy for pheochromocytoma. *J Vet Intern Med* 2008;22:1333–1339.
16. Kyles AE, Feldman EC, De Cock HEV, et al. Surgical management of adrenal gland tumors with and without associated tumor thrombi in dogs: 40 cases (1994–2001). *J Am Vet Med Assoc* 2003;223:654–662.
17. Pey P, Rossi F, Vignoli M, et al. Use of contrast-enhanced ultrasonography to characterize adrenal gland tumors in dogs. *Am J Vet Res* 2014;75:886–892.
18. Gregori T, Mantis P, Benigni L, et al. Comparison of computed tomographic and pathologic findings in 17 dogs with primary adrenal neoplasia. *Vet Radiol Ultrasound* 2015;56:153–159.
19. Labelle P, De Cock HEV. Metastatic tumors to the adrenal glands in domestic animals. *Vet Pathol* 2005;42:52–58.
20. Nieman LK. Approach to the patient with an adrenal incidentaloma. *J Clin Endocrinol Metab* 2010;95:4106–4113.

From this month's *AJVR*

Assessment of left ventricular volume and function in healthy dogs by use of one-, two-, and three-dimensional echocardiography versus multidetector computed tomography

Katherine F. Scollan et al

OBJECTIVE
To compare left ventricle (LV) volume and function variables obtained by use of 1-D, 2-D, and real-time 3-D echocardiography versus ECG-gated multidetector row CT (MDCT) angiography, which was considered the criterion-referenced standard.

ANIMALS
6 healthy, purpose-bred dogs.

PROCEDURES
Dogs were anesthetized and administered a constant rate infusion of esmolol, and 1-D, 2-D, and 3-D echocardiography and ECG-gated, contrast-enhanced MDCT were performed. End-diastolic volume (EDV), end-systolic volume (ESV), stroke volume, and ejection fraction (EF) were calculated by use of the Teichholz method for 1-D echocardiography, single-plane and biplane modified Simpson method of disks (MOD) and area-length method for 2-D echocardiography, and real-time biplane echocardiography (RTBPE) and real-time 3-D echocardiography (RT3DE) for 3-D echocardiography. Volumes were indexed to body surface area and body weight. Median values, correlations, and limits of agreement were compared between echocardiographic modalities and MDCT.

RESULTS
EDV and ESV measured by use of RTBPE and RT3DE had the strongest correlations with results for MDCT. Values obtained for EDV, ESV, stroke volume, and EF did not differ significantly between echocardiographic methods and MDCT. Use of RT3DE and RTBPE slightly underestimated EDV, ESV, and EF, compared with values for MDCT, as determined with Bland-Altman analysis.

CONCLUSIONS AND CLINICAL RELEVANCE
Values for EDV and ESV obtained by use of 3-D echocardiography, including RTBPE and RT3DE, had the highest correlation with slight underestimation, compared with values obtained by use of MDCT. This was similar to results for 3-D echocardiography in human medicine. (*Am J Vet Res* 2016;77:1211–1219)

November 2016

See the midmonth issues of *JAVMA* for the expanded table of contents for the *AJVR* or log on to avmajournals.avma.org for access to all the abstracts.