Short Communication

Comparative ultrasonographic and computed tomographic images of the adrenal glands of healthy cats

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Abstract

Feline adrenal disorders that affect the size of the adrenal glands ~~s~~ can be detected by diagnostic imaging including ultrasonography and Computed Tomography (CT). The objectives of this study were to compare the appearance of the adrenal gland in healthy cats between these two techniques and establish the reference values of the CT dimensions of the adrenal gland in cats. We found that there was no significant difference in the length of both adrenal glands between the two techniques but the cranial and caudal heights of the left adrenal glands ~~s~~ and cranial height of the right adrenal gland obtained from the CT images in post-contrast enhanced-phase were significantly thicker than those obtained from ultrasonography. Our results suggest the reference values (mean±SD) of the left adrenal gland length, cranial, and caudal heights as 11.12 ± 2.65, 3.69 ± 0.72, and 3.70 ± 0.77 mm, respectively, and those of the right adrenal gland as 11.00 ± 2.33, 3.80 ± 0.99, and 3.53 ± 0.73 mm, respectively. The dimensions of both adrenal glands obtained from ultrasonography have more positive correlation with the age and body weight of the cats when compared with those obtained from the CT. Different sensitivity between the two techniques might be the cause and the images obtained from ultrasonography might be affected by the positioning and bodyweight of the patient.

Keywords: Adrenal glands, Cats, Computed Tomography, Normal, Ultrasonography

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Introduction

Adrenal glands are important organs in the mammal body. They are paired, ovoid organs localized craniomedially to kidneys in the retroperitoneal space. The normal location of the left adrenal gland is ventrolateral area to the aorta, while the right adrenal gland lies more cranial and dorsolateral to the caudal vena cava. They consist of two layers of tissue which are the adrenal cortex and medulla. The adrenal cortex secretes important steroid hormones such as mineralocorticoids, glucocorticoids, and sex hormones. Apart from this, adrenal medulla secrete catecholamine which regulates the autonomic nervous system (Prentice and Wood, 1975).

Feline adrenal disorders are becoming more recognised nowadays. This may have resulted from an increase popularity in having cats as companion animals and relevant diagnostic techniques are routinely performed. Feline adrenal disorders including Feline Cushing's Syndrome (FCS) and Feline hyperaldosteronism (Conn's syndrome) result in unregulated diabetes mellitus and skin atrophy. (Chiaramonte and Greco, 2007). Differentiation tests such as high dose dexamethasone suppression test, plasma endogenous ACTH concentration and diagnostic imaging have been used to make a definitive diagnosis of these diseases.

Disease that affects the size of the adrenal glands can be detected by diagnostic imaging such as hyperplasia and tumours (Pagani et al., 2016). Congenital adrenal hyperplasia can be found as an autosomal recessive inherited disease in cats (Knighton, 2004; Owens et al., 2012), while various types of primary adrenal tumour have been diagnosed so far (Boord and Griffin, 1999; Millard et al., 2009; Calsyn et al., 2010; Guerios et al., 2015,). However, two main types of primary adrenal tumour in cats are adrenocortical and medullary tumours (pheochromocytoma) (Henry et al., 1993), which can cause an abnormal appearance in adrenal glands (Rossmeisl et al., 2000; Boag et al., 2004; Smith et al., 2012) . As a result, a change in features and the size of feline adrenal glands is becoming more of a concern for the detection of adrenal gland hyperplasia and adrenal gland tumour in cats.

Ultrasonographic imaging of feline adrenal glands is currently assessed by various studies to emphasise the clinical and problematic nature of feline adrenal disorders (Moore et al., 2000; Combes and Saunders, 2014). Ultrasonography has been used widely to detect the size and shape of adrenal glands. To emphasize this, there have been several studies using ultrasonography to visualize adrenal glands in cats. These studies have reported the normal appearance of adrenal glands from healthy cats (Cartee et al., 1993; Combes et al., 2013) and also an abnormal appearance from sick cats with adrenal disorders (Zatelli et al., 2007; Combes et al., 2013). Ultrasonography of adrenal glands is used to diagnose feline related-adrenal diseases. It detects adrenal asymmetry which is good for unilateral adrenal tumours, however, bilateral adrenal tumours may cause misleading results (Zimmer et al., 2000; Zatelli et al., 2007). In addition, ultrasonography has a lower sensitivity to detecting other adrenal disorders involving a high degree of local invasion or mineralization compared to other advance imaging such as Computed Tomography (CT) (Combes and Saunders, 2014).

CT is an advance diagnostic imaging method that uses multiple electromagnetic radiation, x-rays, to provide transverse anatomical images (Goldman, 2007). CT is used widely as a diagnostic tool for various feline diseases such as nasopharyngeal polyps and tympanic bulla disease (Oliveila et al., 2012). In the same way, CT has been used to examine many organs in the abdominal cavity of cats for instance, kidneys and intestines (Reichle et al., 2002; Suwa and Shimoda, 2017). However, there has been no published report of the normal appearance of feline adrenal glands regarding before and after contrast enhanced-CT images yet. Therefore, the objective of this study was to describe the characteristics of feline adrenal glands in healthy cats using CT to establish the reference values for the length and width of these glands.

Materials and Methods

Animals: This study was a retrospective comparison of the CT and ultrasonography images of the adrenal glands of 30 healthy cats presented for a study of the appearance of abdominal lymph nodes. They were divided into three groups as young, mature, and senior cats according to their age (Table 1). All cats were physically normal from physical examination, with a complete blood count and blood chemistry evaluation, and serologic examination for infectious diseases including Feline Leukemia Virus (FeLV) and Feline Immunodeficiency Virus (FIV). Cats with abnormal results were excluded from this study.

Abdominal Ultrasonography: Dorsal recumbency positioned cats were placed in a V-shaped pad. Cat skin was clipped over the abdominal region, cleaned with 70% alcohol solution, and then covered with contact gel at both sides of the abdominal wall. B mode ultrasonography was performed using a linear microconvex transducer operating at 7.0 MHz (LOGIQ P6, GE Thailand) to view the shape, dimension and the echogenicity of the adrenal glands. The transducer was placed in a sagittal plane to visualize the adrenal glands. The left adrenal gland was imaged craniolateral to the aorta and cranial to the left renal artery, while the right adrenal gland was visualized dorsolaterally to the caudal vena cava. A transverse ultrasonography was not the main procedure as the short axis obtained from this procedure is considered unreliable in cats (Combes and Saunders, 2014).

Computed Tomography: Mature cats were forbidden food and water 6-8 hours prior to anaesthesia, while young cats had it withheld for 4 to 6 hours. Acepromazine (0.03 mg/kg) and atropine (0.04 mg/kg) were administered intramuscularly (IM) as the sedative agents. Then, the cats were anesthetized with propofol (4 mg/kg, intravenously (IV)) as an induction anesthetic. After intubation, anesthesia was maintained with the inhalation of isoflurane 1-2 % in oxygen. A CT scan was then performed after placing the cats in sternal recumbency with the head pointing to the 64-slice CT gantry (64-slice helical CT unit; Optima CT660®, GE Thailand).

After the scout phase, a Field of View (FOV) was created to cover from the 13th vertebral column to the perineum to obtain pre- and post-contrast enhanced-images. Then, CT scanning for the pre-contrast enhanced-phase was done using a low pass filter, 1.25 mm sliced thickness before injecting non-ionic, iodine contrast medium, iohexol (Omnipaque 300®, Cork, Ireland) (300 mg I/kg), into the cephalic vein as a post-contrast enhanced-phase. CT images were recorded in DICOM files for analysis. Images were then processed using the Osirix® program to obtain values of long and short axis of both adrenal glands.

Table 1 Groups of cats involved in this study

Clinical Features			Values
No. of patient			
	Overall		30
	Young (G1; 0-7 months)		10
	Mature (G2; 8-83 months)		10
	Senior (G3; ≥84 months)		10
Sex			
	Overall		
		Female (Intact/spayed)	18 (8/10)
		Male (Intact/spayed)	12 (6/6)
	Young (G1; 0-7 months)		
		Female (Intact/spayed)	5 (4/1)
		Male (Intact/spayed)	5 (5/0)
	Mature (G2; 8-83 months)		
		Female (Intact/spayed)	6 (4/2)
		Male (Intact/spayed)	4 (1/3)
	Senior (G3; ≥84 months)		
		Female (Intact/spayed)	7 (7/0)
		Male (Intact/spayed)	3 (3/0)
Age (months)	Overall		
		Mean±SD	44.80±46.06
		Range	(4.00-132.00)
	Young (G1; 0-7 months)		6.10±1.28
		Mean±SD	(4-7)
		Range	
	Mature (G2; 8-83 months)		
		Mean±SD	22.7±12.03
		Range	(11-48)
	Senior (G3; ≥84 months)		
		Mean±SD	105.6±19.43
		Range	(84-132)
Weight (kg)	Overall		
		Mean±SD	3.45 ± 1.13
		Range	(1.5-5.7)
	Young (G1; 0-7 months)		
		Mean±SD	2.78±0.80
		Range	(1.5-4.1)
	Mature (G2; 8-83 months)		
		Mean±SD	3.33±1.27
		Range	(1.5-4.7)
	Senior (G3; ≥84 months)		
		Mean±SD	4.11±0.84
		Range	(2.9-5.7)
Breed	Overall		
		DSH	23
		Mixed breed	3
		Scottish Fold	2
		American Short Hair	1
		Persian	1
	Young (G1; 0-7 months)		
		DSH	10
	Mature (G2; 8-83 months)		
		DSH	6
		Mixed breed	3
		American Short Hair	1
		Persian	1
	Senior (G3; ≥84 months)		
		DSH	8
		Scottish Fold	2

Statistical analysis: The Computed tomographic and ultrasonographic measurements were compared using paired student's t-test and the results were considered significant at $p < 0.05$. Pearson correlation test was used to determine the relation between the size of the adrenal glands and the age, body weight, and sex of the cats.

Results and Discussion

Of the thirty cats included in this study twelve were males (six were intact and six were castrated) and eighteen females (eight were intact and ten were spayed). Most of them were Domestic Short Hair (DSH) and some were Scottish Fold, Persian, American short hair and mixed breeds. The average Body Condition Score (BCS) and weight was 3.16 ± 0.83 and 3.45 ± 1.13 kg, respectively.

The shapes of both adrenal glands were bilobed and similar to each other. Most of them were a hypoechoic structure surrounded by hyperechoic area (Figure 1A-B). The left adrenal gland localized at the cranial and medial to the left kidney and lateral to the aorta, while all the right adrenal gland was at the cranial and medial to the right kidney and lateral to the caudal vena cava. Microscopic mineralization was found as a faint small hyperechoic focus in the adrenal gland in one cat (Figure 2A). Of the left adrenal grand, the mean±SD of ultrasonologic measurement of length, cranial, and caudal heights were 10.65 ± 2.59, 3.10 ± 0.86, and 3.04 ± 0.66 mm, respectively, while those of the right adrenal glands were 11.32 ± 2.26, 3.24 ± 0.80, and 3.24 ± 0.95 mm, respectively. The cranial height of the left adrenal gland and length of the right adrenal gland have a positive correlation with age (Pearson r = 0.36 and 0.47, respectively). In addition, there were positive correlations between body weight and the cranial height and length of the left adrenal gland the length, cranial, and caudal heights of the right adrenal gland, (Pearson r = 0.36, 0.53, 0.67, 0.52, and 0.45, respectively) (Figure 3). However, when comparing between groups, the length of the adrenal glands tends to increase with age but no significant difference was found between groups, except the length of right adrenal gland in senile cats (12.05 ± 2.12) was significantly longer than young cats (10.18 ± 1.96), (P value = 0.009).

Sagittal views were selected to measure the width of the adrenal gland in both pre- and post-contrast-enhanced phases. In general, both adrenal glands on the sagittal and dorsal planes were round to oval in shape (Figure 1C-E). In the pre-contrast enhanced-phase, the mean±SD of the left adrenal gland length, cranial, and caudal heights were 10.88 ± 1.73, 3.47 ± 0.62, and 3.65 ± 0.62 mm, respectively, while those of the right adrenal glands were 10.26 ± 2.36, 3.49 ± 0.75, and 3.39 ± 0.67 mm, respectively. In addition, we found distinct adrenal mineralization in the pre-contrast enhanced-phase in the same cats that had the mineralization by ultrasonography. In the post-contrast enhanced-phase, the mean±SD of the left adrenal gland length, cranial, and caudal heights were 11.12 ± 2.65, 3.69 ± 0.72, and 3.70 ± 0.77 mm, respectively, while those of the right adrenal gland were 11.00 ± 2.33, 3.80 ± 0.99, and 3.53 ± 0.73 mm, respectively. There were no significant differences in the measured dimensions of the gland between pre- and post-contrast enhanced-phases. In contrast to ultrasonography, no correlation between the size of both adrenal glands and age or body weight was found by the CT images, except for the positive correlation between the cranial height of the left adrenal glands and body weight (Pearson r = 0.47) (Figure 4). In the same way, no significant difference in these values was found between groups of cats divided by their age and body weight.

Compared to ultrasonography, the cranial and caudal heights of the left adrenal gland obtained from the CT images in both phases were thicker than those obtained from the ultrasonography (p = 0.03 and 0.0002, respectively, in the pre-contrast enhanced-phase and p = 0.0005 and 0.0002, respectively, in the post-contrast enhanced-phase). In addition, the cranial and caudal heights of the right adrenal gland obtained from the CT images in the post-contrast enhanced-phase also tended to be thicker than those obtained from the ultrasonography but significant difference was found only in the cranial height between the two methods (p = 0.008).

The mean±SD of pre-contrast enhanced-attenuation value of the left adrenal gland was 32.96 ± 12.77 HU, while that of the right adrenal gland was 32.14 ± 11.04 HU. The mean ±SD of post contrast enhanced-attenuation values of the left adrenal gland was 148.13 ± 44.50 HU, while that of the right adrenal gland was 151.82 ± 49.11 HU. The differences between the HU values were not statistically significant except for the difference between the pre- and post-contrast enhanced-phases. The attenuation values of both left and right adrenal glands obtained from the post-contrast enhanced-phase were significantly higher than those of the pre-contrast enhanced-phase ($p < 0.0001$).

In this study, both adrenal glands were imaged by ultrasonography and CT scan. According to ultrasonography, the location and appearance of the adrenal glands agree with those of other studies (Combes et al., 2013; Combes and Saunders, 2014). Regarding the length, cranial and caudal heights, we found that the average length of the healthy cat's left adrenal gland (of 10.65 ± 2.59 mm which agreed with other reports (8.90 - 10.70 mm) (Combes and Saunders, 2014). However, the cranial and caudal heights of the left adrenal gland in this study were slightly thinner (3.10 ± 0.86, and 3.04 ± 0.66 mm, respectively) than those of other reports (3.50 - 4.30 mm, respectively) (Combes and Saunders, 2014). This may result from the biologic variation among the cats and different sensitivity of the ultrasonography. The right adrenal glands in this study were slightly larger than the left glands which were similar to other's finding (Combes and Saunders, 2014). The average length, cranial and caudal heights of the right adrenal glands were 11.32 ± 2.26, 3.24 ± 0.80, and 3.24 ± 0.95 mm, respectively, compared to other's finding (9.80 - 10.80 mm and 3.60 - 4.30 mm, respectively) (Combes and Saunders, 2014). In addition, the size of the adrenal glands tends to increase with age and bodyweight. However, no significant difference was found between groups of the cats and this needs further investigation. This study agrees with other studies in dogs and cats that age and body weight has little effect on the size of the adrenal gland (Douglass et al., 1997; Combes et al., 2013; Soulsby et al., 2015) .

From ultrasonography and CT, adrenal mineralization was found in the same cat, of 11 months old, as an incidental finding. Adrenal mineralization is one of the characteristics of adrenal tumor (Grooters et al., 1996; Besso et al., 1997), but one study stated that it was not specific for the adrenal glands and could be found in normal cats as an age-related change (Howell and Pickering, 1964). From this study, adrenal mineralization can be detected more clearly with CT compared to ultrasonography, especially in the pre-contrast enhanced-phase. However, it depends on the degree of mineralization and ultrasonic plane waves.

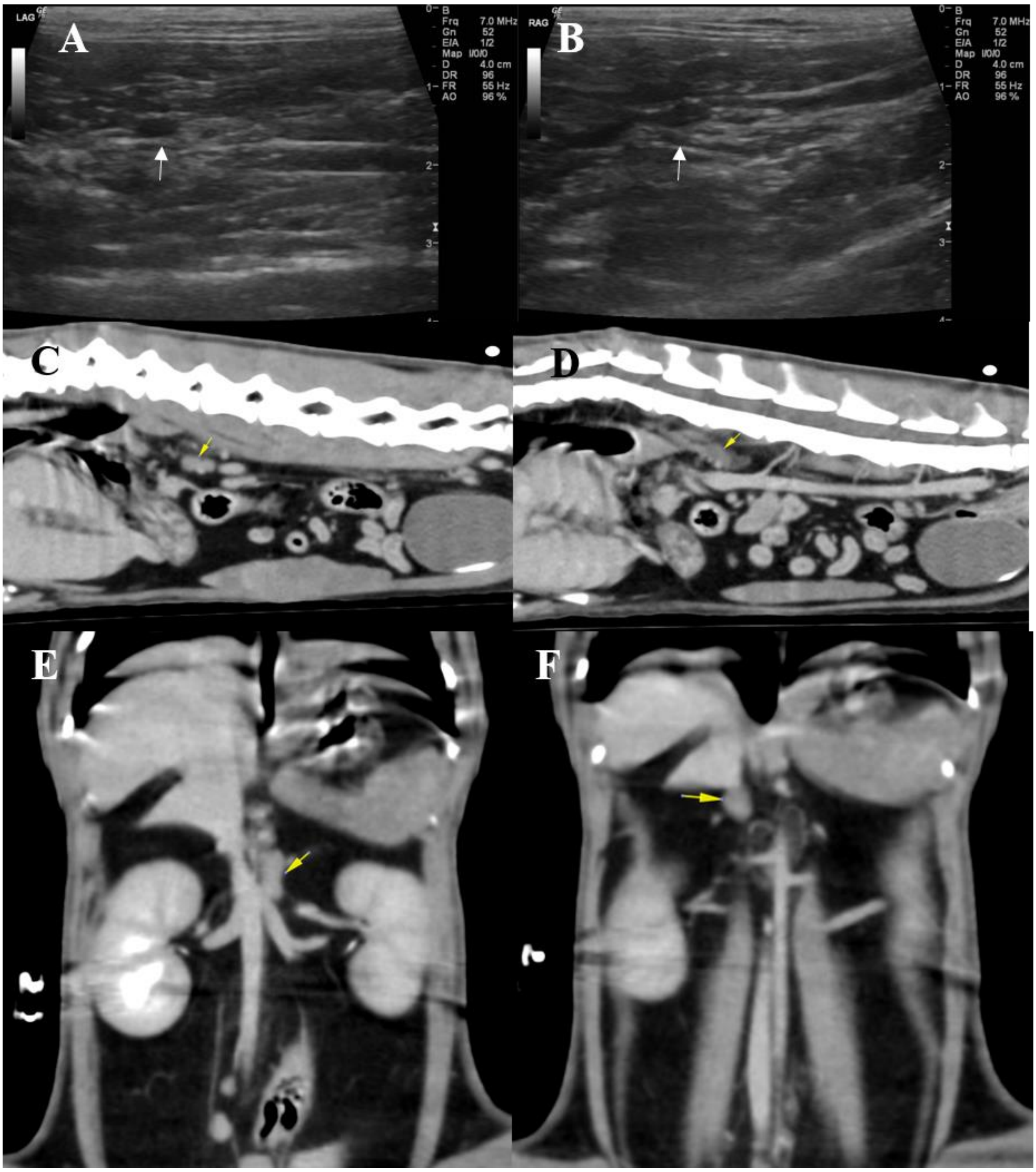

Figure 1 Adrenal glands in a healthy cat (arrows). Ultrasonographic images of the left (A) and right (B) adrenal glands. CT images of the left (C, sagittal view and D, dorsal view) and right (D, sagittal view and E, dorsal view) adrenal glands.

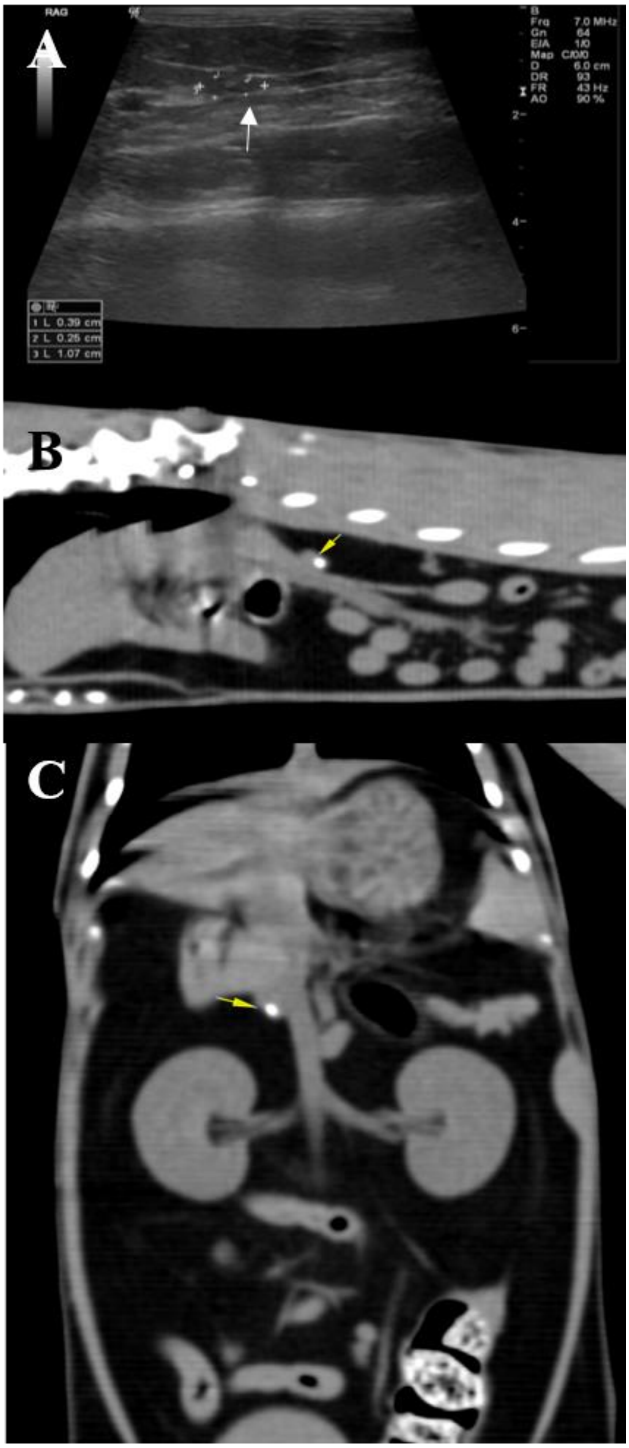

Figure 2 Adrenal mineralization (arrows) imaged by ultrasonography (A) and CT (B, sagittal view and C, dorsal view).

By CT scan, post-contrast enhanced-images were more appropriate to identify adjacent structure around both adrenal glands. However, there was no significant difference in the length, cranial and caudal heights of the glands between the pre- and post-contrast enhanced-phases. However, the attenuation value in the post-contrast enhanced-image was significantly higher than the pre-contrast enhanced-images. We report the normal value of these phases, which might be helpful for differentiating adrenal tumor in cats. The attenuation value can be used for the detection of adrenal adenoma in humans (Korobkin et al., 1996).

In the present study, the cranial and caudal heights of the left adrenal gland and the cranial height of the right adrenal gland measured from the CT images in the post- contrast enhanced-phase were significantly thicker than those measured by the ultrasonography. This might result from the differences in positioning of the cats and in sensitivity between the two techniques. As previously reported, the ultrasonographic scanning in a sagittal plane of the glands obtained the cranio-caudal length longer than the transverse plane of the body (Combes and Saunders, 2014).

Regarding the age and body weight of the cats, we found no significant correlation with the sizes of adrenal glands obtained by CT. These findings were similar to those reported by other studies in dogs (Bertolini et al., 2006). According to the study in humans, CT scans have higher sensitivity, specificity and accuracy when compared to ultrasonography. The images obtained from the ultrasonography might be affected from the positioning and body weight of the patient (Abrams et al., 1982).

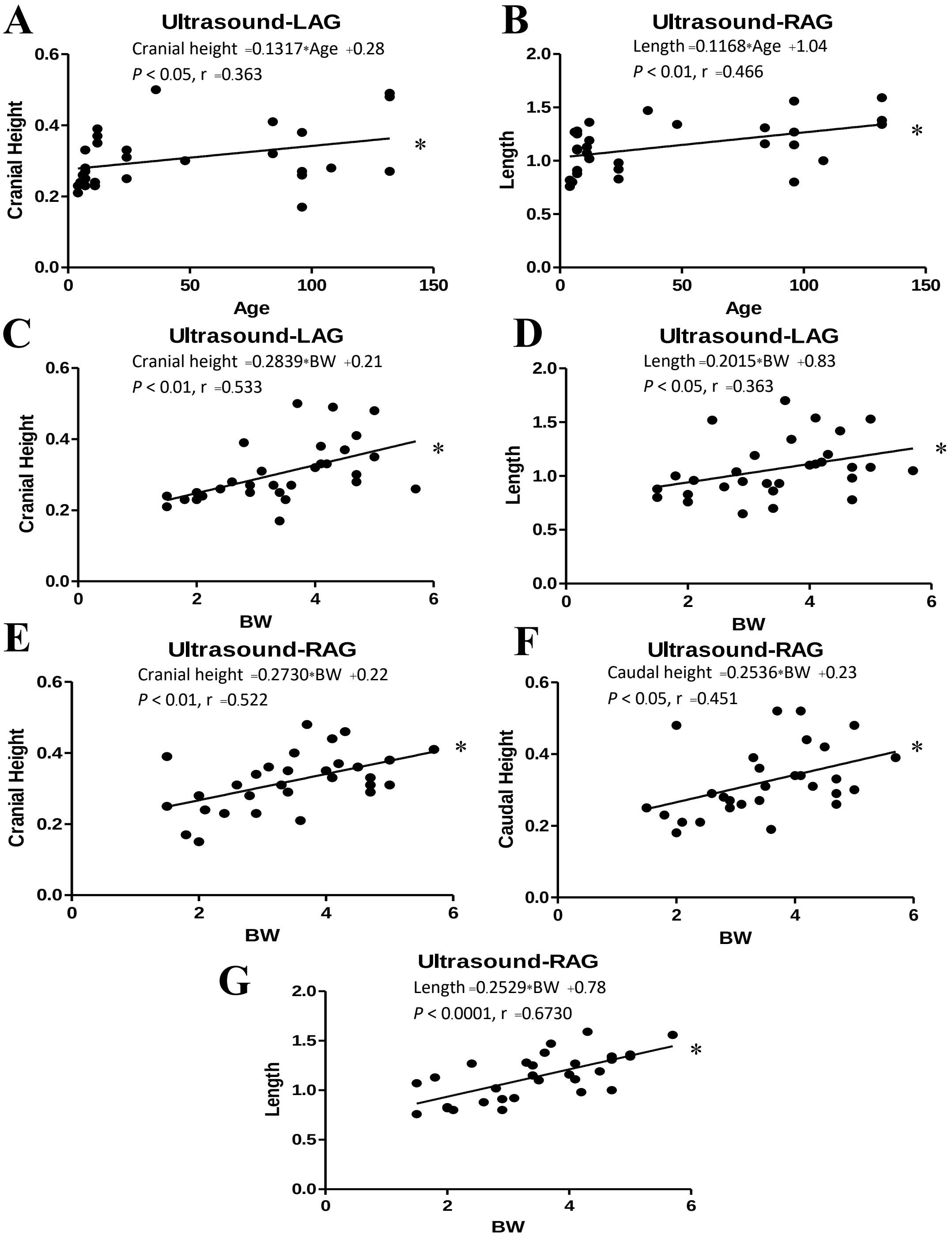

Figure 3 Correlations of age with cranial height of the left adrenal gland (A), and with length of the right adrenal gland (B) from ultrasonography. Correlations of body weight with cranial height (C) and length (D) of the left adrenal glands, and with cranial (E), caudal (F), and length (G) of the right adrenal gland from ultrasonography (* = p<0.05, r<0).

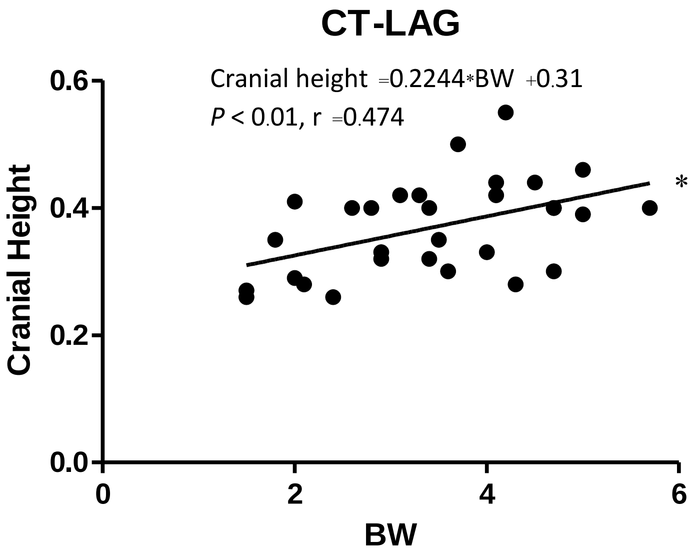

Figure 4 Correlation of body weight with cranial height of the left adrenal gland from CT (* = p<0.05, r<0).

In conclusion, the normal CT image values of the normal adrenal glands of healthy cats are reported to be reference values. Also, CT is one of the alternative techniques to visualize the adrenal gland in cats.

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บทคัดย่อ

การเปรียบเทียบลักษณะของภาพต่อมหมวกไตในแมวปกติที่ได้จากการบันทึกภาพคลื่นเสียงความถี่สูงและการถ่ายภาพรังสีส่วนตัดอาศัยคอมพิวเตอร์

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ความผิดปกติของต่อมหมวกไตในแมวที่มีผลกระทบต่อขนาดและรูปร่างของต่อมหมวกไตสามารถตรวจพบได้ด้วยวิธีทางภาพวินิจฉัย อาทิ การบันทึกภาพคลื่นเสียงความถี่สูงและการถ่ายภาพรังสีส่วนตัดอาศัยคอมพิวเตอร์ การศึกษานี้มีจุดประสงค์เพื่อเปรียบเทียบลักษณะของต่อมหมวกไตในแมวปกติที่มีสุขภาพดีจากการบันทึกภาพคลื่นเสียงความถี่สูงและการถ่ายภาพรังสีส่วนตัดอาศัยคอมพิวเตอร์และรายงานค่าปกติของขนาดของต่อมหมวกไตในแมวจากการถ่ายภาพรังสีส่วนตัดอาศัยคอมพิวเตอร์ โดยการศึกษาครั้งนี้พบว่าความยาวของต่อมหมวกไตที่วัดจากทั้งสองวิธีไม่มีความแตกต่างอย่างมีนัยสำคัญทางสถิติ แต่ค่าความกว้างด้านหน้าและด้านหลังของต่อมหมวกไตด้านซ้ายและค่าความกว้างด้านหน้าของต่อมหมวกไตด้านขวาจากภาพรังสีส่วนตัดอาศัยคอมพิวเตอร์มีค่ามากกว่าค่าที่ได้จากการบันทึกด้วยคลื่นเสียงความถี่สูงอย่างมีนัยสำคัญ โดยค่าปกติของความยาว ความกว้างด้านหน้า และ ด้านหลังของต่อมหมวกไตด้านซ้ายจากการศึกษาครั้งนี้มีค่าเท่ากับ 11.12 ± 2.65 3.69 ± 0.72 และ 3.70 ± 0.77 มิลลิเมตรตามลำดับและต่อมหมวกไตด้านขวาเท่ากับ 11.00 ± 2.33 3.80 ± 0.99 และ 3.53 ± 0.73 มิลลิเมตรตามลำดับ นอกจากนี้ขนาดของต่อมหมวกไตจากการบันทึกภาพคลื่นเสียงความถี่สูงยังมีความสัมพันธ์เชิงบวกกับอายุและน้ำหนักตัวของแมวมากกว่าค่าที่ได้จากการถ่ายภาพรังสีส่วนตัดอาศัยคอมพิวเตอร์ ลักษณะดังกล่าวอาจมีผลมาจากความไวและความแม่นยำที่แตกต่างกันระหว่างสองวิธีโดยค่าที่ได้จากการบันทึกภาพคลื่นเสียงความถี่สูงอาจได้รับผลกระทบจากการจัดท่าทางระหว่างการบันทึกภาพและน้ำหนักตัวของแมวมากกว่าการถ่ายภาพรังสีส่วนตัดอาศัยคอมพิวเตอร์

คำสำคัญ: ต่อมหมวกไต แมว ภาพรังสีส่วนตัดอาศัยคอมพิวเตอร์ ปกติ การบันทึกภาพคลื่นเสียงความถี่สูง

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