Effect of propofol anesthesia on ultrasonographic measurements of the adrenal glands of healthy cats

Het effect van propofolanesthesie op echografische metingen van de bijnieren van gezonde katten

[1] A. Combes, [1]E. Vandermeulen, [2]L. Duchateau, [1]K. Peremans, [3]M. Hesta, [1]J.H. Saunders

[1]Department of Veterinary Medical Imaging, Faculty of Veterinary Medicine, Ghent University, Salisburylaan 133, B-9820 Merelbeke
[2]Department of Comparative Physiology and Biometry, Faculty of Veterinary Medicine, Ghent University, Salisburylaan 133, B-9820 Merelbeke
[3]Department of Nutrition, Genetics and Ethology, Faculty of Veterinary Medicine, Ghent University, Salisburylaan 133, B-9820 Merelbeke

anais.combes@ugent.be

ABSTRACT

Although real-time ultrasonography is feasible in awake cats, cats are frequently anesthetized with propofol, if they are uncooperative or during perioperative ultrasonographic examinations. Propofol induces hypotension in cats and may cause venous vasodilation that redistributes blood volume in abdominal organs and organomegaly. In this paper, ultrasonographic adrenal measurements are compared before and during intravenous propofol anesthesia in healthy cats. No significant effect of propofol anesthesia on adrenal size was found, and the observed differences were small and clinically irrelevant. Therefore, it can be concluded that propofol anesthesia does not prevent ultrasonographic diagnosis of adrenomegaly.

SAMENVATTING

Hoewel real time-echografie mogelijk is bij wakkere katten, worden ze vaak met propofol onder anesthesie gebracht voor echografisch onderzoek in het geval ze moeilijk handelbaar zijn of als perioperatieve onderzoeken nodig zijn. Propofol kan bij katten hypertensie veroorzaken en mogelijk vasodilatatie teweegbrengen, hetgeen leidt tot redistributie van het bloedvolume in abdominale organen en eventueel tot organomegalie. In de voorliggende studie werden echografische metingen van de nieren van gezonde katten vergeleken voor en tijdens de intraveneuze toediening van propofol. Er werd geen significant effect gevonden van propofol op de grootte van de bijnieren; de geobserveerde verschillen waren klein en klinisch irrelevant. Hierdoor kan geconcludeerd worden dat het gebruik van propofol geen invloed heeft op de echografische diagnose van adrenomegalie.

INTRODUCTION

Ultrasonography of the feline adrenal glands has been described in healthy and sick cats, either with or without sedation or anesthesia (Cartee et al., 1993; Zimmer et al., 2000; Kley et al., 2007; Zatelli et al., 2007; Combes et al., 2012; Combes et al.; 2013) (Table 1). Ultrasonographic changes in the adrenal glands have also been reported in hyperaldosteronism, hyperadrenocorticism, sex hormone-producing tumor and pheochromocytoma in cats (Feldman and Nelson, 2003).

With new real-time, high-definition, ultrasound devices and increased experience of most of the ultrasonographers, ultrasonographic examination of the feline adrenal gland is nowadays a quick procedure, feasible in awake cats in the majority of cases (Zimmer et al., 2000). Nevertheless, during perioperative examinations or in aggressive cats, ultrasound has to be performed under sedation or anesthesia. However, anesthetics often induce cardiovascular changes and some create morphological changes that may be detected by imaging. For instance, during computed tomography, propofol has been demonstrated to induce splenomegaly within 10 minutes after intravenous administration while this has not been observed

Table 1. Ultrasonographic measurements of the adrenal glands in healthy and chronically sick cats.

		Healthy cats (n=94)	**Healthy anesthetized cats** (n=10)	**Healthy cats** (n=20)	**Sick cats without endocrinopathies** (n=24)	**Chronically sick cats** (n=51)	**Diabetic cats** (n=20)
		Mean ± SD Median (range)	Mean ± SD	Median (range)	Mean ± SD Median (range)	Mean ± SD Median (range)	Median (range)
Left adrenal gland	Length	10.4 ± 1.8 10.5 (5.8-14.1)	10.7 ± 0.4	8.9 (4.5-13.3)	11.3 ± 2.8 10.6 (7.1-19.5)	10.8 ± 2.0 10.7 (6.9-15.5)	9.8 (7.1-11.3)
	Cranial height	3.8 ± 0.8 3.8 (1.8-5.9)	4.3 ± 0.3	3.9 (3.0-5.3)	3.8 ± 0.8 3.6 (2.8-4.7)	4.2 ± 0.9 4.3 (2.3-5.8)	3.5 (2.4-4.6)
	Caudal height	3.6 ± 0.7 3.5 (2.3-5.5)				3.9 ± 0.8 3.9 (2.0-6.1)	
Right adrenal gland	Length	10.8 ± 1.9 10.8 (6.1-17.7)	10.7 ± 0.4	9.8 (6.7-13.7)	9.8 ± 2.4 9.9 (5.4-13.7)	10.9 ± 2.0 11.0 (6.7-14.7)	10.1 (4.6-13.2)
	Cranial height	3.7 ± 0.9 3.7 (1.5-6.7)	4.3 ± 0.3	3.9 (2.9-4.5)	4.5 ± 1.0 4.2 (3.4-7.1)	4.0 ± 1.2 4.1 (1.5-7.5)	3.6 (2.6-4.8)
	Caudal height	3.6 ± 0.7 3.7 (2.4-5.3)				3.9 ± 1.0 4.0 (1.6-6)	
Reference		Combes et al., (2013)	Cartee et al., (1993)	Zimmer et al., (2000)	Zatelli et al., (2007)	Combes et al., (2013)	Kley et al., (2007)

with ultrasonography (O'Brien et al., 2004; Baldo et al., 2012). The mechanism behind drug-induced organomegaly is complex and not fully understood. However, smooth-muscle relaxation inducing hypotension and increased blood volume in abdominal organs has been the most commonly reported hypothesis (Baldo et al., 2012). Systemic hypotension and abdominal venous vasodilation have been detected by direct pressure measurements in dogs anesthetized with propofol (Goodchild and Serrao, 1989). Propofol-induced hypotension has also been described in cats (Akkerdaas et al., 2001). The redistribution of the blood volume within abdominal organs may also induce organomegaly in cats.

The aim of this study was to evaluate whether morphological changes of the adrenal glands of healthy cats can be observed using ultrasonography after an intravenous propofol bolus, and whether it is diagnostically relevant. This study is a preliminary study in a research project about feline adrenal ultrasound in healthy and sick cats.

MATERIAL AND METHODS

The study population consisted of twenty purpose-bred, group-housed cats. The cats were considered healthy based on physical examination, urinalysis (specific gravity and dipstick), complete blood count, serum biochemistry, including serum potassium concentration and preanesthetic systemic blood pressure measurement.

The study protocol was approved by the Ethical Committee of the Faculty of Veterinary Medicine of Ghent University (n° EC2012/190).

The anesthetic protocol included intravenous injection of propofol (Propovet Multidose 10 mg/ml, Abbott Laboratories Ltd, Maidenhead, UK), through a cephalic venous catheter, starting with a 2-ml bolus and continuing on demand. The total dose of propofol per cat was recorded.

Ultrasonographic examination of the adrenal glands lasted less than five minutes. It was performed before and 15 minutes after anesthesia induction, with a multifrequency linear transducer set on 13 MHz (CX-50, Philips Medical Systems, Brussels, Belgium). The abdomen was clipped before anesthesia. Both pre and postanesthetic examinations were performed with the cats in dorsal recumbency. The cats were restraint manually before anesthesia and not restraint during anesthesia. Coupling gel was applied.

The adrenal glands were imaged according to a previously described protocol (Zimmer et al., 2000; Combes et al., 2013). The maximum length (craniocaudal, L) and the height of the cranial (crH) and caudal (cdH) poles (dorso-ventral) were measured on a sagittal scan of each adrenal gland. The diameter of the abdominal aorta at the level of the adrenal glands was also measured in a longitudinal axis. All the measurements were obtained during the examination by a single ultrasonographer (AC). Additionally, all the images were recorded and remotely reviewed to check for sufficient image quality.

The ultrasonographic adrenal measurement before and during anesthesia was compared using a paired t-test with the cat as blocking factor. In a second analysis, it was investigated whether the within-cat difference between pre and peranesthetic measurements was influenced by the different continuous covariates (preanesthetic systolic blood pressure, age, propofol dose) using a t-test. The influence of gender on this difference was studied using the Fischer's exact test. Finally, the relationship between the difference in adrenal measurements and the difference in aortic

Table 2. Ultrasonographic measurements of the adrenal glands and the aortic diameter before and during propofol anesthesia. The difference in ultrasonographic adrenal measurement before and during anesthesia was performed using a paired t-test with the cat as blocking factor.

Location		Before propofol (Mean +/- SD)	After propofol (Mean +/- SD)	Difference (Mean+/- SE)	P-value
Left adrenal gland	Length	9.7 +/- 1.7	9.9 +/- 1.5	0.22 +/ 0.36	0.5603
	Cranial height	3.5 +/- 0.9	3.7 +/- 0.8	0.23 +/ 0.13	0.0934
	Caudal height	3.8 +/- 0.6	3.7 +/- 0.9	-0.11 +/ 0.16	0.5122
Right adrenal gland	Length	10.8 +/- 1.9	10.8 +/- 1.7	0.02 +/ 0.21	0.9432
	Cranial height	3.9 +/- 0.8	3.9 +/- 0.7	0.02 +/ 0.15	0.9195
	Caudal height	3.9 +/- 0.7	3.9 +/- 0.8	0.02 +/ 0.16	0.9270
Aortic diameter		4.5 +/- 0.6	4.3 +/- 0.5	-0.18 +/ 0.12	0.1769

diameters during and before anesthesia, were investigated using Pearson correlation coefficients.

RESULTS

All twenty cats were Domestic Shorthairs, including three entire males, four castrated males, ten entire females and three neutered females. Mean age with standard deviation (SD) was 4.4 ±2.4 years. Mean weight with SD was 3.7 ±1.0 kg. Mean preanesthetic systolic blood pressure was 118 mmHg (SD = 12 mmHg). No relevant hematological or biochemical abnormalities were detected in urine or blood analysis.

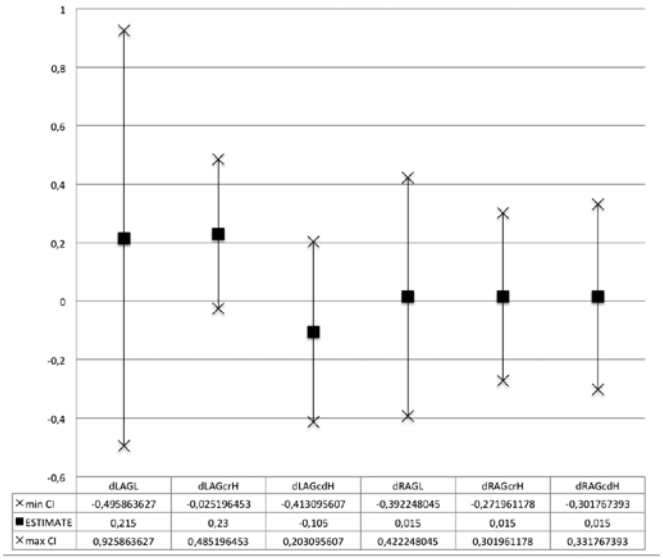
The injected volume of propofol for anesthesia ranged from 2,5 to 6 ml (median 4 ml), corresponding to a dose of 8 to 18.8 mg/kg (median 10 mg/kg).

Ultrasonographic adrenal measurements before and during anesthesia are summarized in Table 2. No significant differences were found between pre and peranesthetic measurements (P>0.05).

The estimated difference before and during propofol anesthesia and its 95% confidence interval for the different ultrasonographic adrenal measurements are presented in Figure 1.

No statistically significant effect of gender, age, blood pressure and propofol dose were detected on the difference between the ultrasonographic adrenal gland measurements before and during anesthesia.

Difference in aortic diameter was not correlated to the difference in adrenal measurements when comparing before and during propofol anesthesia (all Pearson coefficients < 0.39).



dLAGL: difference in length of left AG, dLAGcrH: difference in cranial height of left AG, dLAGcdH: difference in caudal height of left AG, dRAGL: difference in length of right AG, dRAGcrH: difference in cranial height of right AG, dRAGcdH: difference in caudal height of right AG.

Figure 1. Estimate and 95% confidence interval of the difference in ultrasonographic adrenal measurements before and during propofol anesthesia in cats (in mm).

DISCUSSION

No significant difference in ultrasonographic adrenal size was detected between preanesthetic and peranesthetic measurements when using intravenous propofol. Similarly, the adrenal ultrasonographic measurements reported in a previous study on anesthetized cats showed comparable measurements as

those in awake cats, although the cats were anesthetized with atropine and pentobarbital (Cartee et al., 1993).

When using intravenous propofol, the observed differences between preanesthetic and peranesthetic measurements were small and clinically irrelevant. Based on their 95%-confidence intervals, it can be concluded that the difference for left adrenal length is contained in the interval [-0.50;0.93], for left cranial adrenal height in the interval [-0.03;0.49] and for left caudal adrenal height in the interval [-0.41;0.20]. The differences for the right gland were even smaller.

In previous ultrasonographic studies, the change in adrenal size of cats with adrenal diseases has been evaluated. The adrenomegaly was significant enough to assume that propofol does not prevent ultrasonographic diagnosis of adrenomegaly in cats with adrenal diseases. In a study by Combes et al. (2012), the adrenal glands of hyperthyroid cats showed similar or mildly enlarged measurements with mean measurement differences of 1.6-1.7 mm in length and 0.8-0.9 mm in height. In cats with hyperaldosteronism secondary to an adrenal carcinoma, the adrenal mass has been reported as at least twice the normal adrenal size on ultrasound, or more than 10 and 3 mm difference in length and height measurements, respectively (Combes et al., 2013).

Enlargement of any abdominal organ during propofol anesthesia could be expected based upon the cardiovascular effect of propofol. Redistribution of blood in the abdominal venous circulation has been described secondary to propofol-induced hypotension and venous vasodilation in dogs (Baldo et al., 2012). Propofol has an increased systemic vascular capacitance as a result of an inhibition of sympathetic nervous system in rats (Hoka et al., 1998). Propofol-induced hypotension has been studied in vitro and a smooth muscle relaxation has been induced by propofol with a lower dose in the vein than in the artery (Bentley et al., 1989). These findings have been hypothesized by the authors in a computed tomographic study of propofol-induced splenomegaly in dogs (Baldo et al., 2012). Even though the adrenal glands are richly vascularized and contain large cortical arterial and medullary venous sinuses, the potential smooth muscle relaxation and vasodilation induced by propofol may not be sufficient to change significantly the ultrasonographic size of the glands (Hullinger, 2013). Although propofol-induced systemic hypotension has also been described in cats, the blood redistribution hypothesis has not been studied in this species (Akkerdaas et al., 2001).

In the present study, adrenal ultrasonography in anesthetized cats appeared to be easier than in awake cats. Abdominal muscle relaxation allowed better skin contact and better pressure from the transducer. The immobile animal with slower breathing pattern provided better image quality and a more comfortable examination to the ultrasonographer. The adrenal glands of the anesthetized cat appeared easier to be found and could be better delineated, which allowed for more accurate measurements under anesthesia. Preanesthetic measurements may be impeded by breathing or motion thus under or overestimating the real adrenal size and creating a difference in adrenal measurements between preanesthetic and peranesthetic examination. However, the accuracy of the measurements was not tested in this study, as the authors could not compare ultrasonographic measurements to a gold standard reference, such as gross measurements, for obvious, ethical reasons.

The preanesthetic ultrasonographic procedure was performed under manual restraint and might have induced acute stress in some cats, which is not the case during the peranesthetic procedure. As the medulla of the adrenal gland is considered as postganglionic sympathetic neurons, it is involved in epinephrine and norepinephrine secretion, especially in stressful situations (Guyton and Hall, 2006). The effect of this physiologic phenomenon on the adrenal ultrasonographic appearance is not known.

In conclusion, no change in ultrasonographic adrenal measurements secondary to intravenous propofol anesthesia in cats could be detected. Intravenous propofol is not likely to influence the ultrasonographic diagnosis of adrenal diseases. Propofol can be used in uncooperative cats or in perioperative cases for the evaluation of feline adrenals without effect on the morphological appearance of the adrenal glands.

REFERENCES

Akkerdaas LC, Minch P, Sap P, Hellebrekers LJ (2001). Anaesthesiology: Cardiopulmonary effects of three different anaesthesia protocols in cats. *Veterinary Quaterly 23*, 182-186.

Baldo CF, Garcia-Pereira FL, Nelson NC, Hauptman JG, Shih AC (2012). Effects of anaesthetic drugs on canine splenic volume determined via computed tomography. *American Journal of Veterinary Research 73*, 1715–1719.

Bentley GN, Gent JP, Goodchild CS (1989).Vascular effects of propofol: smooth muscle relaxation in isolated veins and arteries. *Journal of Pharmacy and Pharmacology 41*, 797-798.

Cartee RE, Finn Bodner ST, Gray BW (1993). Ultrasound examination of the feline adrenal gland. *Journal of Diagnostic Medical Ultrasound 9*, 327-330.

Combes A, Pey P, Paepe D, Rosenberg D, Daminet S, Putcuyps I, Bedu AS, Duchateau L, de Fornel-Thibaud P, Benchekroun G and Saunders JH (2013). Ultrasonographic appearance of adrenal glands in healthy and sick cats. *Journal of Feline Medicine and Surgery 15*, 445-457.

Combes A, Vandermeulen E, Duchateau L, Peremans K, Daminet S, Saunders JH (2012). Ultrasonographic measurements of adrenal glands in cats with hyperthyroidism. *Veterinary Radioliogy and Ultrasound 53*, 210-216.

Feldman EC, Nelson RW (2003). Hyperadrenocorticism in cats (Cushing's syndrome). In: Feldman EC, Nelson

RW (eds.). *Canine and Feline Endocrinology and Reproduction*. Third Edition, Philadelphia, WB Saunders, p 358-392.
Goodchild CS, Serrao JM (1989). Cardiovascular effects of propofol in the anaesthetized dog. *British Journal of Anaesthesiology 63*, 87-92.
Guyton A.C., Hall J.E (2006). The autonomic nervous system and the adrenal medulla. In: A.C. Guyton, J.E. Hall (eds.). *Textbook of Medical Physiology*. Eleventh edition, Elsiever Saunders, Philadelphia, p 750.
Hoka S, Yamaura K, Takenaka T, Takahashi S (1998). Propofol-induced increase in vascular capacitance is due to inhibition of sympathetic vasoconstrictive activity. *Anesthesiology 89*, 1495-1500.
Hullinger RL (2013). The endocrine system. In: H.E. Evans, A. de Lahunta (eds.). *Miller's Anatomy of the Dog*. Fourth edition. Elsevier Saunders, St Louis, p 421.
Kley S, Alt M, Zimmer C, Hoerauf A, Reusch CE (2007). Evaluation of the low-dose dexamethasone suppression test and ultrasonographic measurements of the adrenal glands in cats with diabetes mellitus. *Schweizer Archive für Tierheilkunde 149*, 493-500.
O'Brien R.T, Waller K.R, Osgood TL (2004). Sonographic features of drug-induced splenic congestion. *Veterinary Radiology and Ultrasound 45*, 225-227.
Zatelli A, D'Ippolito P, Fiore I, Zini E (2007). Ultrasonographic evaluation of the size of the adrenal glands of 24 diseased cats without endocrinopathies. *Veterinary Record 160*, 658-660.
Zimmer C, Hörauf A, Reusch C (2000). Ultrasonographic examination of the adrenal gland and evaluation of the hypophyseal-adrenal axis in 20 cats. *Journal of Small Animal Practice 41*, 156-160.

DE NACHTZWALUW: MELKDIEF EN MASTITISVERWEKKER

"De nachtzwaluw is een vogel die van God gemaakt is om bij nachte het venijn (schadelijk ongedierte) *te pakken, dat in de lucht vliegt en om de beesten verkeert. Hij is onhoorbaar in zijn vlugge, heeft eenen bek die wijd opengaat tot onder zijne oogen. (...).*

Dit is de waarheid, maar haddet gij over (voor) *twee, drie duust jaar de geleerden en nu nog sommige lieden onder 't volk te rade geweest, zij hadden u gansch een andere historie van de nachtzwaluw uiteen gedaan. Een groot wijde bek, bij nachte vliegen, gezien geweest omtrent koeien of geetenuiers - om kwellend ongedierte te vangen - dat ongedierte, dat, ongevangen, ontstekingen veroorzaakt op de uierspenen, 't was genoeg: de nachtzwaluw melkt bij nachte de melkkoeien en trekt de geeten drooge, zeide men, en alle beesten die hij gemolken heeft, besmet hij den aan den uier.*

Dat is onwaarheid, die bij alle natiën tot nog onlangs voor waarheid aangenomen werd en 't bewijs daarvan zit in de namen; aigitheles heet (noemt) *hem Aristoteles, de groote wijzaard, en hij beschuldigt hem daarbij openlijk* (van) *melkdieverije; caprimulgus heet hij in 't Latijn, goatsucker in 't Engelsch, Milchsauger in 't Duitsch, tette-chèvre in 't Fransch. In 't Vlaamsch en kenne ik hem maar eenen name, die hem wonder wel past, en die hem van alle andere vogels onderscheiden houdt, te weten nachtzwalm of nachtzwaluwe."*

Nvdr: ***Aegotheles*** is een geslacht van vogels uit de familie van de dwergnachtzwaluwen *(Aegothelidae),* voorkomend in Azië en Australië. Onze **nachtzwaluw (*Caprimulgus europaeus*)** behoort tot de nachtzwaluwenfamilie (Caprimulgidae), niet verwant met de zwaluwen of de gierzwaluwen. In het Nederlands kent men ook de benaming **geitenmelker**, een letterlijke vertaling van het Latijnse *Caprimulgus*.

Uit: Guido Gezelle's *Uitstap in de Warande* (1865-1870 en 1882, 6de uitgave 1927, De Meester, Wetteren, 1927).

L. Devriese