Ovarian remnant syndrome in small animals: case series

Kiki Mullikin,[a] Michael Byron,[b] Janice Chen,[c] Soon Hon Cheong,[b]
Cathy Gartley,[c] Mariana Diel de Amorim[b]
[a]Laurel Highlands Animal Health, Somerset, PA
[b]Cornell University College of Veterinary Medicine, Ithaca, NY
[c]Ontario Veterinary College, University of Guelph, Guelph, Canada

Abstract

Our objective was to report the utility of various diagnostic tests in identifying ovarian remnant syndrome (ORS) in dogs and cats. Medical records from 2 referral teaching hospitals (Health Sciences Centre at the Ontario Veterinary College and Cornell University Hospital for Animals) were examined and 48 animals (31 dogs and 17 cats) were chosen. Data included were based on sufficient clinical or diagnostic evidence of ORS. Histopathology was used as the confirmatory test for ORS. There was no difference between the proportions of dogs versus cats diagnosed with ORS. Similarly, there was no difference in the proportions of ovarian remnants (OR) between large, medium, or small dogs, or the side (right, left, or bilateral) in which OR was diagnosed. Vaginal cytology and transabdominal ultrasonography findings, and serum progesterone concentrations had the highest chance of correctly identifying an OR prior to exploratory surgery. Transabdominal ultrasonography had strong agreement with OR location identified at surgery. Presumptive intraoperative diagnosis of OR was possible in 39/41 cases (95.1%). Auxiliary diagnostic testing should be recommended to confirm functional ovarian tissue before surgery to reduce unnecessary surgery. Additionally, transabdominal ultrasonography examination may reduce surgical time since ovarian remnant location has strong agreement with surgical findings.

Keywords: Dogs, cats, ovarian remanent, anti-Müllerian hormone, progesterone concentrations, transabdominal ultrasonography

Introduction

Ovarian remnant syndrome (ORS) is defined as the presence of functional gonadal tissue in a bitch or queen that had undergone a previous ovariectomy or ovariohysterectomy (OHE).[1,2] Clinical presentations of ORS include: mammary gland enlargement or masses, pollakiuria and stranguria, vulvar or vaginal masses, polyuria and polydipsia, recurrent urinary tract infection, and vaginal discharge and pseudopregnancy.[3,4] Presence of functional ovarian remnant tissue is most often the result of incomplete surgical removal. It can also be the result of dropping a tissue fragment into the surgical site or failing to identify and remove ectopic ovarian tissue.[4-6] Studies on surgical complications of postOHE reported that 17 - 43% of the referral cases, presented for postoperative complications after ovariohysterectomy, were for ORS.[7,8] Animal's age, breed, body condition, whether the surgical procedure was elective or emergent, and the experience of the surgeon were not associated with a higher likelihood of ORS.[4,9] However, in a larger scale and in a more recent study that examined the medical records of 1,880 bitches, higher weight was associated with more postOHE complications, including ORS.[10] Relating to this aspect of surgical access, the right ovary (located more cranially) was the more common site for finding an ovarian remnant compared to left.[11,12] Additionally, reports vary on whether ORS is more common in dogs or cats,[4,9] with some authors suggesting a higher likelihood in dogs due to the presence of its unique ovarian bursa.[3,13]

The mean time to recurrence of estrous behavior following spay is reportedly 1.3 years in dogs and 3 years in cats.[1,3,4] Most commonly reported clinical signs are associated with proestrus and estrous signs.[3] Vaginal discharge may or may not be present depending on the amount of uterine stump left at OHE; other differentials for vaginal discharge such as coagulopathies, vaginitis, trauma, vaginal neoplasia, and vaginal foreign bodies should be ruled out.[4]

Diagnosis of ORS can be presumptive based on clinical signs or supported by ancillary testing such as, vaginal cytology, measuring estradiol and progesterone concentrations (before and after stimulation with gonadotropin releasing hormone [GnRH] or human chorionic gonadotropin [hCG]) or luteinizing hormone (LH) or anti-Müllerian hormone (AMH) or via ultrasonography.[1,3,9,11,14] Vaginal cytology (based on abundance of superficial epithelial cells) is the cheapest and

fastest method for presumptive diagnosis of ORS in dogs and cats presenting with proestrus or estrus clinical signs.[1,4] Vaginal cytology results are useful to determine the presence of functional ovarian tissue and endogenous estrogen secretions; however, exogenous and adrenal estrogen exposure should be ruled out.[15] Additionally, vaginal cytology in cat presents both a challenge to obtain and to interpret.[16] Serum estradiol concentrations > 20 pg/ml are indicative of ORS in a OHE dog. However, reliability of estradiol as a marker of ORS is limited because it is not produced solely by the ovaries; furthermore, it varies on a daily, weekly, and seasonal basis, and also there is variability among dogs.[17] Serum LH concentrations are expected to be elevated in spayed animals due to lack of negative feedback of estradiol;[1] however, a false positive could occur if the test is performed on the day of an LH peak in dogs, or false negative if the test is performed during the period of shorter day length in cats.[18] Baseline progesterone concentrations are very reliable as it is an indication of active luteal tissue in the dog, and remain elevated for 4 months of the year in most dogs. However, in queens, progesterone concentrations are not useful indicator of the presence of functional ovarian tissue unless ovulation has been induced.[9] Anti-Müllerian hormone in adult females is secreted exclusively by granulosa cells of the ovary and therefore has been used as a serum biomarker for ORS.[19] However, AMH results can be inconclusive in remnant ovarian tissues that have corpora lutea. Therefore, AMH and progesterone tests should be performed together for higher accuracy. Additionally, AMH has not been thoroughly investigated in prepubertal bitches that could lead to false negative results. Despite its limitations, AMH and progesterone have become the gold standard diagnosis of ORS prior to surgical exploration.[14]

Use of transabdominal ultrasonography in detecting ovarian remnants continues to be debated; the successful diagnosis of ORS depends on the skill of the examiner, the size of the remnant, and estrous cycle stage.[1,19] A study reported that ultrasonography was more helpful as an ancillary test to history and clinical signs rather than a replacement to hormonal testing.[3] Additionally, in 32 dogs with ORS transabdominal ultrasonography was able to identify a remnant in 30 out of 31 dogs (97%) that had a remnant confirmed via histopathology examination.[11]

Exploratory laparotomy/laparoscopy is the treatment of choice for ORS and histopathology is considered the definitive diagnosis.[1,11] Our objective was to describe the most common clinical features, signalment of animals diagnosed with ORS and diagnostic tools utilized.

Materials and methods

Medical records from 2 referral veterinary teaching hospitals from 1984 to 2020 were reviewed to identify dogs and cats with a history of previous OHE that presented with clinical signs of estrus and/ or clinical signs that led to the presumptive diagnosis of ORS. Cases were included if sufficient clinical or diagnostic evidence of an OR was present. Diagnosis of ORS was via vaginal cytology, serum estradiol concentrations, serum progesterone concentrations (> 0.5 ng/ml),[14] measurement of progesterone concentrations after an gonadotropin stimulation test, AMH concentrations, identification of ovarian remnant via transabdominal ultrasonography by a board-certified radiologist or radiology resident, identification of an ovary during an exploratory laparotomy/laparoscopy, histopathology, or any combination of these techniques. Cases referred for ORS but did not have confirmation of ovarian remnant via histopathology, at surgery, or via vaginal cytology in combination with progesterone analysis were excluded.

Following information, if available, was collected: species, breed, size of breed (small, medium or large), age at presentation, age at OHE, time from spay to clinical signs, presenting complaint, clinical signs observed by the owner and the attending veterinarian, results of vaginal cytology, serum estradiol, progesterone, LH, or AMH concentrations, transabdominal ultrasonography findings, side of suspected ovarian remnant via ultrasonography (right, left or both), surgical approach for exploratory laparotomy (ventral midline or laparoscopy), side of the remnant at surgery (right, left or both), and histopathological diagnosis.

Data analyses

Statistical analysis was performed with JMP Pro software version 16 (SAS Institute Inc., Cary, NC, USA), with a level of significance of $p < 0.05$. Fischer's Exact test was performed to test the differences in the proportions of species, breed size, and ovarian remnant side at surgery. A Kappa coefficient of agreement was used to determine the correlation between ovarian remnant side diagnosed via transabdominal ultrasonography to surgery findings.

Results

Forty-eight animals (31 dogs and 17 cats) were diagnosed with ORS. Dog population consisted of small, medium, and large breed dogs that included 10 Labrador retrievers and 12 mixed breed dogs. Remaining breeds were Akita, Boston Terrier, Brittany Spaniel, Brussels Griffon, Kerry Blue Terrier, Pug, Rottweiler, German Short-haired Pointer, and West Highland White Terrier. In the cat population, 13 were Domestic Shorthair, with the remainder comprised of a Himalayan, a Bengal, and 2 Domestic Longhair cats. The median and interquartile range age at presentation was 2.3 (1.4 - 5.7) years, whereas the age at presentation for dogs and cats respectively was 3.5 (1.6 - 5.9) years and 1.5 (1 - 3.5) years. The median and interquartile time between previous ovariohysterectomy and presentation of clinical signs resembling ORS was 0.5 (0.3 - 2) years, whereas for dogs and cats the median and interquartile range were 1.0 (0.3 - 2.8) years and 0.5 (0.3 - 0.8) years, respectively. There was no difference in the proportion of dogs versus cats diagnosed with ORS or between the proportion of large breed dogs (36.7%) compared to medium (36.7%) and small dogs (26.7%). There was no difference in the proportions of the location of the OR, where 8.5% of the cases were identified in both locations, 40.4% were identified on the left side and the remaining 51.0% were on the right.

As per owners, 45 of 48 animals (93.8%) exhibited classical signs of ORS. These signs included bloody vaginal discharge, vulvar swelling, and attracting males in dogs and rolling, vocalizing, and attracting males in cats (Table 1). Of those animals presenting for classical signs of estrus, vaginal cytology

was performed on 24 animals (50.0%), and 12/24 of these animals had a cytological finding consistent with estrous smear (50.0%). The remaining 12 vaginal cytology were classified as proestrus, diestrus, or inconclusive. Seven of those cytology had concurrent progesterone concentrations consistent with ovarian function (> 0.5 ng/ml) and 4 had progesterone concentrations that were < 0.5 ng/ml. Progesterone concentrations were not analyzed in 1 remaining dog.

Table 1. Number of affected animals and percentage of affected cases out of total number of cases by presenting clinical signs

Clinical sign	Number affected	Percent affected
Dogs (n = 31)		
Vulvar swelling	23	74.2
Bloody vaginal discharge	20	64.5
Cats (n = 17)		
Vocalizing	13	76.5
Dogs and cats combined (n = 48)		
Mammary development	10	20.8
Attracting males	6	12.5
Abdominal/mammary neoplasia	3	6.3
Surgical complications of previous OHE	2	4.2

Serum estradiol concentrations were measured in 4 animals (8.5%); 2 of these had serum estradiol concentrations > 20 pg/ml. Baseline serum progesterone concentrations were measured in 16 dogs (51.6%). Of these 16 dogs, 10 had serum progesterone concentrations > 0.5 ng/ml (62.5%). Measurement of serum progesterone concentrations after stimulation with hCG or GnRH was performed in 6 cats and 1 dog (14.6%). Serum progesterone concentrations increased > 0.5 ng/ml in all 6 cats, but not in the dog in response to hCG or GnRH stimulation; however, this dog had positive estradiol concentrations and ovarian remnant was identified via surgery and histopathology. An in-house LH test was performed in 5 animals (3 dogs and 2 cats) that correctly identified ORS in 4/5 (80%) of animals and subsequently confirmed via histopathology. In 1 case ORS was not identifiable via LH concentrations and progesterone concentrations of this dog was < 0.2 ng/ml; however transabdominal ultrasonography and surgery correctly identified OR that was confirmed via histopathology. AMH assays were performed in 6 animals (5 dogs and 1 cat) (12.5%); 3/5 dogs tested positive, whereas the other 2 were inconclusive. However, progesterone concentrations on these were > 0.5 ng/ml and surgery/histopathology confirmed the presence of an ovarian remnant. The single cat that had the AMH performed was positive for AMH and that was confirmed via histopathology. Diagnostic examinations and clinical findings in 48 cases are listed (Table 2). Cases that were correctly diagnosed with various diagnostic tests compared to histopathology confirmation of OR are identified (Table 2).

Table 2. Diagnostic examinations and clinical findings

Case	Species	Breed	Age at presentation (years)	Presenting complaint	Vaginal cytology*	P_4 † (ng/ml)	AMH	LH	Ultrasonography findings	Surgical approach	OR at Surgery	Surgery/histology findings
1	Dog	Labrador retriever	5.9	Estrous signs						Ventral Midline	Right (+)	Right ectopic OR, bilateral paraovarian cyst (+)
2	Dog	Mixed	7.3	Caudal abdominal mass					Renal Cyst (-)	Ventral Midline	Both (+)	Ovarian tissues and uterine horn
3	Dog	Akita	1.4	Estrous signs	Inc	27.66				Ventral Midline	Right (+)	Right entire ovary normal (+)
4	Dog	Mixed	9.4	Estrous signs	Diestrus	0.13			Uterine stump (-)	Ventral Midline	Right (+)	Right granulosa cell tumor (+)
5	Dog	Labrador retriever	4.3	Estrous signs		0.38‡				Ventral Midline	Left (+)	Mass resembling ovarian tissue§

Case	Species	Breed	Age at presentation (years)	Presenting complaint	Vaginal cytology*	P_4 † (ng/ml)	AMH	LH	Ultrasonography findings	Surgical approach	OR at Surgery	Surgery/histology findings
6	Dog	Labrador retriever	5.6	Estrous signs					Right ovary (+)			
7	Dog	Rottweiler	6.8	Postspay complication					Inconclusive (-)	Ventral Midline	Left (+)	Left ovarian tissue (+)
8	Dog	Labrador retriever	3.5	Estrous signs						Ventral Midline	Right (+)	Right OR w/ CL and follicles (+)
9	Dog	Mixed	2.2	Estrous signs						Ventral Midline	Right (+)	Right OR w/ CL (+)
10	Dog	Mixed	1.7	Estrous signs					Right ovary w/ CL (+)	Ventral Midline	Right (+)	Right ovary w/ CL, follicles (+)
11	Dog	Mixed	2.0	Estrous signs					Intact right ovary and uterine horn remnant (+)	Ventral Midline	Right (+)	Right ovary, uterine tube
12	Dog	Mixed	1.3	Estrous signs	Estrus					Ventral Midline	Right (+)	OR with CL, uterine tube (+)
13	Dog	Mixed	13.4	Estrous signs					Caudal abdominal mass (-)	Ventral Midline	Left (+)	Left OR with granulosa cell tumor (+)
14	Dog	Brittany Spaniel	0.8	Estrous signs	Estrus	1.68			Right ovary w/ cystic structures (+)	Ventral Midline	Right (+)	Right entire ovary w/ CL and follicles (+)
15	Dog	Boston Terrier	6.1	Estrous signs	Proestrus	0.03	+					
16	Dog	Labrador retriever	2.2	Estrous signs	Proestrus/ Diestrus	0.61	Inc		Right OR (+)	Laparoscopy	Right (+)	Right ovary
17	Dog	Mixed	1.1	Estrous signs					Right OR (+)	Ventral Midline	Right (-)	Right ovary w/ CL and follicles (+)
18	Dog	Mixed	9.7	Estrous signs	Proestrus/ Diestrus	31.4	+		Left OR (+)			
19	Dog	Pug	5.9	Estrous signs	Diestrus				Large mid-abdominal mass (-)	Ventral Midline	Left (+)	Left ovary w/ cyst (+)
20	Dog	Labrador retriever	6.4	Vomiting, diarrhea		5.1			Right OR (+)	Ventral Midline	Right (+)	Right ovary w/ CL and paraovarian cyst (+)
21	Dog	Mixed	3.7	Estrous signs	Proestrus/ Diestrus	3.5	+		Right OR w/ CL (+)	Ventral midline	Right (+)	Right OR w/ CL (+)
22	Dog	German Short-Haired Pointer	4.1	Estrous signs	Proestrus/ Diestrus	0.78	Inc		Right OR (+)	Ventral Midline	Right (+)	Right OR w/ multiple CL (+)
23	Dog	Westie	3.6	Estrous signs					Right OR and oviduct (+)	Ventral Midline	Right (+)	Entire ovary, uterine tube (+)
24	Dog	Brussels Griffon	5.7	Estrous signs	Proestrus/ Diestrus	0.34			Uterine stump (-)	Ventral Midline	Both (+)	Left granulosa cell hyperplasia and right hydrosalpinx (+)
25	Dog	Labrador retriever	1.4	Estrous signs	Diestrus	0.44			OR (unknown location) (+)	Laparoscopy	Right (+)	Endometrial hyperplasia and focal hydrosalpinx (-)
26	Dog	Mixed	2.3	Estrous signs	Estrus	0.2		-		Laparoscopy	Right (+)	Right ovarian remnant and hydrosalpinx (+)
27	Dog	Kerry Blue Terrier	1.4	Estrous signs	Diestrus	0.57		+	Right OR (+)	Laparoscopy	Right (+)	Ovarian remnant and hydrosalpinx (+)

Case	Species	Breed	Age at presentation (years)	Presenting complaint	Vaginal cytology*	P_4 † (ng/ml)	AMH	LH	Ultrasonography findings	Surgical approach	OR at Surgery	Surgery/histology findings
28	Dog	Mixed	3.0	Estrous signs	Estrus				Right ovary (+)	Laparoscopy	Right (+)	OR w/ CL (+)
29	Dog	Mixed	2.0	Pseudo-pregnancies					Bilateral ovaries and cyst-like oviductal structures (+)	Laparoscopy	Both (+)	Left and right ovarian remnant, cystic remnant of uterine horn (+)
30	Dog	Soft-coated Wheaten Terrier	1.0	Estrous signs	Diestrus	20.0		+	Right ovary (+)	Ventral Midline	Right (+)	Ovotestis w/ CL (+)
31	Dog	Labrador retriever	1.6	Estrous signs		0.57			Left OR (+)	Laparoscopy	Left (+)	Granulosa cell hyperplasia, CL, uterine tube (+)
32	Cat	DSH	10.3	Mammary tumors; cyclicity						Ventral Midline	Left (+)	OR (follicles and CL); mammary gland adenocarcinoma and ductal carcinoma (+)
33	Cat	Himalayan	10.7	Estrous signs					Large abdominal mass suspect of ovarian tumor (+)	Ventral Midline	Both (+)	Granulosa cell tumor (+)
34	Cat	DSH	1.8	Estrous signs	Estrus					Ventral Midline	Right (+)	Follicles, granulosa cells (+)
35	Cat	DLH	3.4	Estrous signs						Ventral Midline	Left (+)	Left cystic ovary w/ luteinization (+)
36	Cat	DSH	1.5	Estrous signs		7.34**			Left ovary (+)	Ventral Midline	Left (+)	Left ovary w/ CL and follicles (+)
37	Cat	DSH	0.8	Estrous signs					Uterine stump (-)	Ventral Midline	Left (+)	Left ovary w/ follicles (+)
38	Cat	DSH	2.4	Estrous signs					Left ovary w/ follicles or CL (+)	Ventral Midline	Left (+)	Left ovary w/ follicles (+)
39	Cat	DLH	1.0	Estrous signs						Ventral Midline	Left (+)	Left entire ovary
40	Cat	DSH	0.7	Estrous signs					Left OR w/ follicles (+)	Ventral Midline	Left (+)	Left ovary, uterine tube (+)
41	Cat	DSH	1.0	Estrous signs	Estrus	0.93**			No OR (-)	Laparoscopy	Left (+)	Left ovary w/ CL and follicle (+)
42	Cat	DSH	3.5	Estrous signs					Left ovary (+)	Laparoscopy	Left (+)	Left granulosa cell hyperplasia (+)
43	Cat	DSH	1.1	Estrous signs	Estrus	4.87**		+	Left OR (+)	Laparoscopy	Left (+)	Entire normal ovary (+)
44	Cat	DSH	1.2	Estrous signs	Estrus	7.58**				Laparoscopy	Left (+)	Normal ovarian tissue (+)
45	Cat	DSH	1.1	Estrous signs	Estrus	6.23**				Laparoscopy	Right (+)	Normal ovarian tissue, oviduct (+)
46	Cat	DSH	4.8	Estrous signs	Estrus	10.09**				Ventral Midline	Right (+)	Normal ovarian tissue (+)
47	Cat	Bengal	1.0	Estrous signs	Estrus			+	Left ovary w/ cysts (+)	Laparoscopy	Left (+)	Normal ovarian tissue (+)
48	Cat	DSH	1.5	Estrous signs	Estrus		+		Left OR (+)	Laparoscopy	Left (+)	Ovary w/ CL and cystic rete ovarii (+)
Positive results					12	16	4	4	25		44	39

Case	Species	Breed	Age at presentation (years)	Presenting complaint	Vaginal cytology*	P_4 † (ng/ml)	AMH	LH	Ultrasonography findings	Surgical approach	OR at Surgery	Surgery/histology findings
Negative results					12	6	2	1	8		1	1
Total tested					**24**	**22**	**6**	**5**	**33**		**45**	**41**
Percentage of correctly identified via histopathology as final diagnos					**61.9%**	**83.3%**	**66.6%**		**71.4%**		**95%**	

estrous signs = vulva enlargement + vaginal bleeding in canines; rolling and vocalizing in felines
P_4 = progesterone; OR = ovarian remnant; CL = corpora lutea; Inc = inconclusive
*vaginal cytology only marked positive if in estrus
†progesterone concentrations positive if > 0.5 ng/ml
‡Interpretation of hCG stimulation: progesterone - baseline: 0.38; posthCG (1 hour): 0.18; posthCG (5 hours): 0.31; estradiol - baseline: 37.31; posthCG (1 hour): 65.78; posthCG2 (5 hours): 31.75
surgery/histology report: (+) sign identifies cases which had histopathology performed and therefore description from pathology, otherwise description from surgery finding
§histology report was lost
**serum progesterone samples measured after hCG or GnRH stimulation

Transabdominal ultrasonography was performed by a boar-certified radiologist or a radiology resident in 33/48 animals (68.8%). An ovarian remnant was diagnosed ultrasonographically in 25/33 animals (75.8%). Thirty-one animals that had transabdominal ultrasonography underwent an exploratory laparotomy to remove the remnant. There was no difference between species or size of dog in the probability of identifying an ORS via transabdominal ultrasonography. Ultrasonography identified the side on which the remnant was located in 23/25 cases (92.0%). The Kappa coefficient of agreement of remnant side on transabdominal ultrasonography with the actual side determined at surgery was very strong at 0.7 (0.7, 1) (lower 95% CI, upper 95% CI) ($p < 0.0001$).

Forty-five animals underwent an exploratory laparotomy to remove the OR (93.8%). A ventral midline approach was performed on 31/45 of the animals (68.9%); 14/45 animals underwent a laparoscopic procedure (31.1%). Samples were submitted for histopathology in 41/45 (91.1%) of the animals. An OR was identified in 39/41 (95.1%) of the samples submitted for histopathology; the histopathology report for 1 of the 2 unconfirmed samples could not be located and the other histopathology result was consistent with uterine and oviduct tissue. Two of the 39 ovarian tissue samples were granulosa cell tumors. Both samples belonged to dogs, and the time from OHE to clinical signs for each was 9.4 and 12.4 years, respectively. Example of an OR in a dog is provided (Figure); OR was on the right side of the abdomen (identified via transabdominal ultrasonography and confirmed via histopathology).

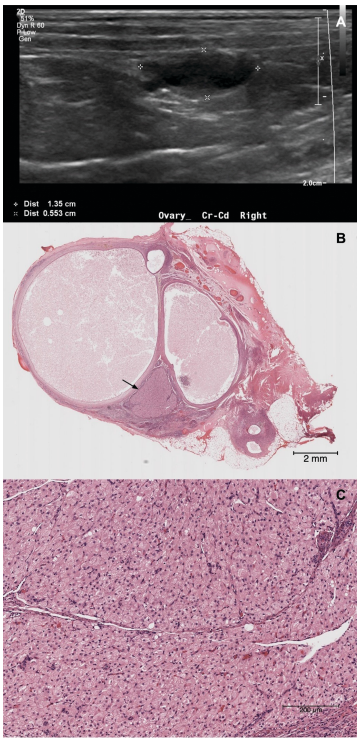

Figure. Ultrasonogram of suspected right gonad (craniocaudal view); note: hypoechoic gonad with multifocal anechoic follicles, presumed to be OR (A); histopathological (H&E stain) confirmation of the right OR surrounded by a thin layer of adipose tissue, with 2 cystic structures surrounded by ovarian stroma and presence of a corpus luteum (arrow) (B), and higher magnification of the corpus luteum demonstrating luteal cells (C).

Discussion

The mean age at presentation for dogs and cats with ORS has been reported to be 2.8 years and the interval between OHE and presentation to be 1.4 years.[3] In our study, the median age at presentation was 2.3 years and the interval between OHE and presentation was 0.5 years, with the owners reporting

signs from immediately after ovariohysterectomy up to 12.4 years later. Data were skewed towards younger animals similar to reports.[3,4] Furthermore, in the clinical history, several owners reported that their animals returned to estrus from very soon after OHE to several months following OHE, but they did not pursue further diagnostics or treatment until later in the animal's life.

Weight may be associated with ORS as a complication postOHE;[4,9,10]" however, not all had similar finding. In our study, we did not evaluate animals' weight as not all of them were available; however, when breed size (small, medium, or large) was evaluated, no difference in the proportion of ORS were present among dog breed sizes. In this regard, some studies have demonstrated that cats are more likely to have ORS,[4,9] but others have demonstrated the opposite.[3,13] In our study, no difference was detected between the proportions of cats and dogs with ORS. However, the number of cats in our study was lower and therefore the data should be interpreted with caution.

When vaginal cytology demonstrated predominantly superficial cells consistent with estrus, not surprisingly all animals were diagnosed on histopathology. Of the 12 cytology that were suspected to be proestrus, diestrus, or undetermined, 7 had serum progesterone concentrations consistent with presence of luteal function (> 0.5 ng/ml) that enabled to confirm the diagnosis of ORS. Four animals had progesterone concentrations < 0.5 ng/ml, and 1 of these 4 cases had ORS confirmed via AMH whereas the other 3 had confirmation at surgery. It is important to note that in cats, progesterone was measured after ovulation induction. These findings supported the importance of multiple diagnostics, as a single cytology sample may not always be enough to determine the stage of the estrous cycle. However, vaginal cytology remains an easy, cheap and simple test to perform and when combining with progesterone measurements will increase the odds of correctly identifying ORS.[1] AMH was only measured in 6 animals. The low number of cases is due to the fact that most of the cases included in this study were seen before AMH testing was available,[19] and because of the high expense to send samples to referral laboratories for AMH testing. Additionally, some of the cases were less complex and presented with more obvious signs of estrus concurrent with corroborating vaginal cytology and/or confirmation with elevated serum progesterone. That serum estradiol was measured only in 4 animals whereas vaginal cytology was performed in 24 cases was most likely due to vaginal cytology being a cheaper, easier, and faster method to diagnose endogenous estrogens with less chances for laboratory reference range, assay and diurnal variations.[17] Clinician preferences, advancement on diagnostic capabilities throughout the years and financial budget could have affected the diagnostic test performed.

In this sample population, no difference in the proportions were noted between right and left OR. This contradicts (right sided remnants were significantly higher than left) certain reports,[3,11] suggesting surgical error. However, others have demonstrated that surgical experience of the veterinarian is not associated with increased chance of complication for ORS.[4,9] This study has not evaluated surgeon's experience, as most of the OR that were diagnosed were referrals, and therefore experience of the veterinarian that performed the original OHE was unavailable. A study with a larger population of dogs and cats would be required to determine if the side of OR and if weight or size of the animals may influence the risk of ORS.

Percentage of correctly identifying an OR via transabdominal ultrasonography was consistent with what was reported.[3] Additionally, of those cases that we were able to identify an ORS via transabdominal ultrasonography, there was a strong agreement of the location of the remnant with surgical findings. Likewise, a study that used transabdominal ultrasonography for prelaparoscopy diagnosis of ORS also demonstrated that transabdominal ultrasonography can be quite reliable in identifying the remnant location.[11] Species or breed size of dog were not associated with whether or not a remnant was identified in transabdominal ultrasonography. However, our study's dog population lacked giant breeds that may be more difficult for the ultrasonographer and machine capabilities. The level of experience of the ultrasonographer performing the examination was not evaluated during this study and could be a confounding factor for the successful diagnosis of an ovarian remnant via transabdominal ultrasonography. We would expect more experienced ultrasonographers to have even higher detection rates. Further studies regarding ultrasonographer's experience (board-certified radiologist versus radiology resident) are warranted with a larger population of animals.

Of the 45 exploratory surgeries performed, 1 was negative for histopathology. In this case, a remnant was identified on the midline via transabdominal ultrasonography and grossly at surgery, but histopathology results revealed cystic endometrial hyperplasia and focal hydrosalpinx. Tissues were not submitted for histopathology in 4 cases that underwent surgery. In all 4 cases, a remnant was identified grossly at surgery. In 3/4 cases, transabdominal ultrasonography and/or progesterone concentrations were used to confirm the presence of an OR prior to surgery, and the remaining case had no diagnostics performed prior to surgery, but a complete ovary was identified at surgery. Similar to our study, identification of ovarian remnants at surgery (gold standard) had a high sensitivity compared to histopathology.[11,12] Surgical removal of ovarian remnants remains the treatment of choice.[1] In our study, vaginal cytology results, serum progesterone concentrations, and transabdominal ultrasonography findings had the highest chance of correctly identifying a OR prior to exploratory surgery, and transabdominal ultrasonography was very effective in locating the remnant side that could help reduce surgical and anesthesia time. Auxiliary diagnostic testing should be recommended to confirm functional ovarian tissue before surgery to reduce the chance of unnecessary surgery. Additional studies are needed to determine which combination of diagnostic tests, in addition to clinical signs, is the most cost effective and accurate method of diagnosing an ovarian remnant prior to pursue an invasive exploratory abdominal surgery.

Acknowledgement

Authors thank Stephen Parry (Cornell Statistical Consulting Unit) for statistical analyses advice and Sarah Lyn Milicic for editorial assistance.

References

1. Johnston SD, Root-Kustritz MV, Olson PNS: Disorders of the canine ovary. In: Johnston SD, Root-Kustritz MV, Olson PNS: editors. Canine and Feline Theriogenology. Philadelphia; Saunders Elsevier: 2001. p. 199-200.

2. Ball BA, Almeida J, Conley AJ: Determination of serum anti-Müllerian hormone concentrations for the diagnosis of granulosa-cell tumours in mares. Equine Vet J 2013;45:199-203.

3. Ball RL, Birchard SJ, May LR, et al: Ovarian remnant syndrome in dogs and cats: 21 cases (2000-2007). J Am Vet Med Assoc 2010;236:548-553.

4. Wallace MS. The ovarian remnant syndrome in the bitch and queen. Vet Clin North Am Small Anim Pract 1991;21:501-507.

5. Diel de Amorim M, Lerer A, Durzi T, et al: Identification of ectopic ovotestis in a dog with XX ovotesticular, SRY-negative, disorder of sexual development. Reprod Domest Anim 2018;53. doi:10.1111/rda.13174

6. Fontes GS, McCarthy RJ: Ovarian remnant syndrome in a cat with ovarian tissue in theomentum. J Am Vet Med Assoc 2020;257:631-634.

7. Okkens AC, Dieleman SJ, v d Gaag I: [Gynaecological complications following ovariohysterectomy in dogs, due to: (1) Partial removal of the ovaries. (2) Inflammation of the uterocervical stump (author's transl)]. Tijdschr Diergeneeskd 1981;106:1142-1158.

8. Pearson H: The complications of ovariohysterectomy in the bitch. J Small Anim Pract 1973;14:257-266.

9. Miller DM: Ovarian remnant syndrome in dogs and cats: 46 cases (1988-1992). J Vet Diagn Invest 1995;7:572-574.

10. Muraro L, White RS: Complications of ovariohysterectomy procedures performed in 1880 dogs. Tierarztl Prax Ausg K Kleintiere Heimtiere 2014;42:297-302.

11. van Nimwegen SA, Van Goethem B, de Gier J, Kirpensteijn J: A laparoscopic approach or removal of ovarian remnant tissue in 32 dogs. BMC Vet Res 2018;14:333. doi:10.1186/s12917-018-1658-y

12. Percival A, Singh A, Gartley C, et al: Single-port laparoscopic treatment and outcome of dogs with Ovarian Remnant Syndrome: 13 Cases (2010-2018). J Am Anim Hosp Assoc 2020;56:114-119.

13. Naiman JH, Mayhew PD, Steffey MA, et al: Laparoscopic treatment of ovarian remnant syndrome in dogs and cats: 7 cases (2010-2013). J Am Vet Med Assoc 2014;245:1251-1257.

14. Place NJ, Cheraskin J-L, Hansen BS: Evaluation of combined assessments of serum anti Mullerian hormone and progesterone concentrations for the diagnosis of ovarian remnant syndrome in dogs. J Am Vet Med Assoc 2019;254:1067-1072.

15. Berger DJ, Lewis TP, Schick AE, et al: Canine alopecia secondary to human topical hormone replacement therapy in six dogs. J Am Anim Hosp Assoc 2015;51:136-142.

16. Johnston SD, Root-Kustritz M V, Olson PNS: Disorders of the feline ovaries. In:Johnston SD, Root-Kustritz M V, Olson PNS: editors. Canine and Feline Theriogenology. Philadelphia; Saunders Elsevier: 2001. p. 457-459.

17. Frank LA, Mullins R, Rohrbach BW: Variability of estradiol concentration in normal dogs. Vet Dermatol 2010;21:490-493.

18. Bateman HL, Vansandt LM, Newsom J, et al: Temporal changes in serum luteinizing hormone following ovariohysterectomy and gonadotropin-releasing hormone vaccination in domestic cats. Reprod Domest Anim 2017;52:332-335.

19. Place NJ, Hansen BS, Cheraskin J-L, et al: Measurement of serum anti-Mullerian hormone concentration in female dogs and cats before and after ovariohysterectomy. J Vet Diagn Invest 2011;23:524-527.