

Findings and prognostic indicators of outcomes for bitches with pyometra treated surgically in a nonspecialized setting

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OBJECTIVE

To determine the rate of survival to hospital discharge and identify indicators associated with poor outcomes among female dogs (bitches) with pyometra treated with ovariohysterectomy (OHE) in a nonspecialized setting.

ANIMALS

405 bitches diagnosed with pyometra at the American Society for the Prevention of Cruelty to Animals Animal Hospital from January 1, 2017, to February 8, 2019.

PROCEDURES

For this retrospective study, medical records were searched and data collected including patient history, clinical signs, serum biochemical analyses results, and outcome (survival to hospital discharge, length of hospital stay, and uterine rupture). Logistic regression models were used to assess multivariable associations and identify potential predictive variables.

RESULTS

The rate of survival to hospital discharge for bitches with pyometra treated with OHE was 97% (394/405); 44% (174/394) stayed in the hospital ≥ 2 nights, and 3% (11/390) had a ruptured uterus. Bitches with a high BUN concentration or heart murmur had greater odds of death after OHE; however, the model had low predictive power. Those with uterine rupture, inappetence, high concentrations of BUN or serum creatinine, low PCV, or dehydration had greater odds of hospitalization ≥ 2 nights. There were no significant predictors of uterine rupture.

CLINICAL RELEVANCE

The rate of survival to hospital discharge was high for bitches with pyometra treated with OHE in a nonspecialized setting; therefore, general practitioners could expect similar outcomes. With this important procedure widely available in general practices, more pets can receive treatment for this life-threatening disease.

In countries where healthy female dogs (bitches) are not commonly spayed, pyometra has been diagnosed in up to 20% of sexually intact bitches before the age of 10.¹ Clinical signs may include dehydration, anemia, polydipsia, polyuria, anorexia, vomiting, diarrhea, lethargy, tachycardia, tachypnea, purulent vaginal discharge (with an open cervix), and fever or hypothermia.²⁻⁶ Signs of pyometra may be subtle at onset, and the disease can progress to an advanced stage by the time clinical signs are readily observed. In advanced stages of pyometra, bitches may suffer from sepsis, endotoxic shock, or systemic inflammatory response syndrome (SIRS), and the disease can be fatal.^{3,4,7,8} Thus, pyometra is typically treated on

an emergent basis.^{3,4} Recommended treatment for pyometra is ovariohysterectomy (OHE) after patient stabilization with fluids and antimicrobials; medical treatment may be considered in mild cases.^{3,7} The mortality rate in bitches after surgical treatment for pyometra is very low (1% [4/315])⁹; abnormal clinical signs and bloodwork dyscrasias typically resolve within a week after surgery.^{10,11}

Although the standard treatment of pyometra is an OHE, affected patients often present in a severely compromised state on an emergency basis; thus, the cost of OHE for pyometra can be more than 10 times that of a routine spay.¹² This financial burden can influence and even preclude

surgical treatment of pyometra; therefore, keeping diagnosis and treatment affordable for owners is essential to increase their access to veterinary care.¹³ The elevated cost of treating a pyometra in an emergency setting could potentially be avoided if private practices would perform OHE on bitches with pyometra, instead of generally referring them for emergency care.

Identifying clinical signs that are associated with postoperative morbidity and death in bitches with pyometra would help veterinarians determine which affected bitches may or may not be appropriately treated in general practice settings, compared with emergency specialty settings. Several papers^{4,9,13,14} document the need for rapid, cost-effective assessments of patients with pyometra and determinants of prolonged hospitalization and increased mortality and complication rates following surgical treatment. Some recent work^{15,16} has addressed this gap. Küplülü et al¹⁵ examined outcomes of 30 bitches with pyometra that were treated with OHE and found that high concentrations of BUN and serum creatinine concentrations were associated with greater postoperative mortality rates. Sant'Anna et al¹⁶ examined hematologic and biochemical characteristics, including blood lactate concentrations in 80 bitches surgically treated for pyometra, and found that the presence of SIRS and high serum concentrations of creatinine were associated with prolonged hospitalization, death, or both. Jitpean et al⁹ identified prognostic indicators of complications and prolonged hospitalization after OHE in a retrospective analysis of 356 bitches with pyometra and found that peritonitis was the most common complication, leukopenia combined with fever or hypothermia was associated with increased risk of peritonitis, and leukopenia, lethargy, and pale mucous membranes were all associated with increased risk of prolonged hospitalization.

Building on the work of Jitpean et al,⁹ Sant'Anna et al,¹⁶ and Küplülü et al,¹⁵ we conducted a retrospective analysis of 405 bitches with pyometra treated with OHE to identify prognostic indicators and inform treatment of pyometra. Because the bitches included in the study reported here were treated with basic, nonspecialized supportive care, our findings would be applicable to general practice clinics. Our objectives were to determine the rate of survival to hospital discharge and identify clinical signs and bloodwork indicators associated with poor outcomes for bitches with pyometra treated with OHE in a nonspecialized setting. This information could help veterinarians determine which affected bitches may require intensive treatment in a specialty setting and which may be appropriate to treat in general practice settings. We aimed to demonstrate that clinical abnormalities in bitches with pyometra resolve quickly after OHE and that mortality rates are low; therefore, treatment in costly specialty settings may not be necessary.

Materials and Methods

The medical records database of the American Society for the Prevention of Cruelty to Animals Animal Hospital (AAH) in New York City was searched for records of bitches of any age that were diagnosed with pyometra at the AAH between January 1, 2017, and February 8, 2019. Diagnosis was made based on patient history, clinical presentation, physical examination findings, and diagnostic imaging. The presence of a fluid-filled uterus on OHE verified the diagnosis of pyometra. Distinguishing among hydrometra, mucometra, and pyometra was not possible with available data in the medical records because neither analyses nor bacterial culture of uterine fluid samples was standard treatment protocol at the AAH; thus, the term pyometra was used for all of these conditions. Because AAH did not perform elective OHEs, incidental pyometra was precluded.

Medical records review and data collection

Presurgical findings—Data extracted from the medical records included signalment; patient history (eg, whether the animal had seen a veterinarian for signs associated with pyometra prior to coming to AAH, duration of signs, and owner-reported signs [eg, diarrhea, inappetence, vomiting, polydipsia, and polyuria]); examination findings (eg, body weight, rectal temperature, open vs closed pyometra, ambulatory vs nonambulatory, signs of depressed mentation, respiratory rate and effort, heart rate, and the presence vs absence of dehydration, ascites, mammary tumors, or heart murmur); hematologic results (eg, PCV and concentrations of blood glucose, BUN, and serum creatinine); dates of hospital admission (intake), OHE, and discharge; and whether the animal died while hospitalized or was discharged or euthanized. We defined the reference range for rectal temperature (38.1 to 39.2 °C) and upper reference limits for respiratory rate (≤ 20 breaths/min), heart rate (≤ 120 beats/min) based on the cutoffs for SIRS.¹⁷ Bitches with rectal temperatures > 39.2 °C or < 38.1 °C were considered febrile or hypothermic, respectively. Heart rates > 120 beats/min were classified as high, and respiratory rates > 20 breaths/min were classified as high. Serum biochemical analyses were performed with point-of-care equipment (i-STAT 1 and i-STAT Alinity, Zoetis Inc), with the reference limits provided by the manufacturer¹⁸ were observed. Of particular interest, serum creatinine concentration > 1.3 mg/dL was defined as high, blood glucose concentration < 60 mg/dL was defined as low, BUN concentration > 26 mg/dL was high, and PCV $< 37\%$ was low. For consistency with other work,^{19,20} age was considered as a categorical variable, with bitches grouped as either ≤ 8 or > 8 years old.

Surgery and hospitalization—All surgeries were performed by veterinarians experienced in general surgery and the AAH standard protocol as previously described.¹⁹ Following OHE, bitches were hospitalized until they were eating appropriately and would

tolerate oral administration of medications. Antimicrobials and analgesics were prescribed at hospital discharge for all bitches.

Because a typical length of stay at the AAH was 1 night following OHE for pyometra, we defined an extended length of stay at the hospital as ≥ 2 nights. As described previously,¹⁹ we accounted for intake on a day before AAH was closed (ie, Sundays and holidays), when animals could not be discharged the day after surgery, by subtracting that extra night's stay from the total length of stay.

Euthanasia or medical treatment—Reasons for euthanasia or medical treatment for pyometra noted in the medical records were recorded. Additionally, when available, clinical signs and bloodwork results for euthanized bitches were recorded for comparison with results for bitches that underwent OHE.

Statistical analysis—Commercially available statistical software (Stata Statistical Software, release 15, StataCorp) was used for all analyses. Normality of results was assessed with the Shapiro-Wilk test. Means and SDs were reported for normally distributed data; medians with the first and third quartiles (1Q and 3Q, respectively) of the interquartile (25th to 75th percentile) ranges (IQRs) were reported for data not normally distributed. Numbers, percentages, and 95% CIs were reported for categorical variables. The Fisher exact test was used for exploratory univariable analysis between the outcome variables postoperative death before hospital discharge, extended length of stay (≥ 2 nights), and whether the uterus was ruptured and the prognostic indicator variables for age > 8 years, body weight < 8 kg, duration of clinical signs, prior visit to a veterinarian for the current pyometra signs, open versus closed pyometra, ambulatory versus nonambulatory, diarrhea, inappetence, vomiting, low PCV at intake, hypoglycemia at intake, hypercreatininemia at intake, high BUN concentration at intake, increased respiratory effort, tachypnea, hypothermia, fever, tachycardia, ascites, dehydration, receipt of a transfusion, mammary tumor, and heart disease. Due to potential concerns that bitches with closed pyometra could have longer durations of clinical signs that could lead to a greater likelihood of death, we also conducted Fisher exact tests to identify associations between the variables for duration of clinical signs and prior visit to a veterinarian with the outcomes of death prior to discharge among bitches with closed pyometra, euthanasia, or OHE to facilitate determining which variables to include in preliminary regression analyses.

Logistic regression models were developed with backward-stepwise selection estimation and the likelihood-ratio test as described previously¹⁹ were used to identify the most parsimonious models for predicting outcomes. Prognostic indicator variables documented in more than 95% of bitches and with a $P < 0.2$ in the exploratory univariable analyses were included in preliminary models as potential predictors of death after OHE and before hospital discharge, extended length of stay (≥ 2 nights), and uterine rupture. Collinearity between variables

was assessed with variance inflation factors (VIFs). Significance was set at $P < 0.05$. Because preliminary models may have had restricted samples due to missing data for some variables, omitted variables in the initial stepwise process were individually re-entered and tested for significance and added back into the model when significant at $P < 0.05$ with the use of a second backward-stepwise process where all variables with a value of $P \geq 0.05$ were removed. The McFadden R^2 , pseudo R^2 values, and Hosmer-Lemeshow goodness-of-fit and likelihood-ratio tests were used to develop and assess the final models as previously described.¹⁹ Odds ratios were calculated. Classification tables with estimated sensitivity and specificity of the model and the predictive power of the final models were compiled.

Results

Animals

There were 450 bitches with pyometra diagnosed at the AAH during the study period. Of these 450 animals, 405 (90%) were treated with OHE, 26 (6%) were euthanized, and 19 (2%) were treated medically. For the 405 bitches treated with OHE, the mean \pm SD age was 8 ± 3 years (range, < 1 to 18 years), median weight was 7.8 kg (range, 1.3 to 59.0 kg; IQR, 4.4 to 22.0 kg), and the median number of postoperative nights in the hospital was 1 night (range, 0 to 5 nights; IQR, 1 to 2 nights; **Table 1**). Also, of the 405 bitches treated with OHE, 228 (56%) had been seen previously by a different veterinarian, 174 (44%) had extended (≥ 2 nights) stays in the hospital after OHE, and 11 (3%) died postoperatively. Surgery reports were available for 390 of these animals, of which 11 (3%) had uterine rupture identified during surgery. The overall mortality rate during the study period for bitches treated with OHE was 3% (11/405; 95% CI, 1 to 5%).

Evaluation for predictive variables

Univariable associations between outcomes (ie, death, extended length of stay, ruptured uterus, or euthanasia) and potential predictor variables of interest were compiled (**Supplementary Table S1**). Additionally, when only bitches with closed pyometra and recorded duration of clinical signs ($n = 64$) were considered, the likelihood of postoperative death before hospital discharge did not differ significantly ($P = 0.62$) between those with a history of clinical signs > 1 -week duration ($n = 30$) and those with clinical signs < 1 -week duration (34). Of those with a prior visit to a veterinarian for the current pyometra infection documented in the medical record, none of the 4 bitches that had closed pyometra and died postoperatively had been seen previously by a veterinarian, whereas all 43 animals with closed pyometra that had been seen previously by a veterinarian survived. The likelihood of postoperative death did not differ for bitches that required versus did not require a transfusion, and neither advanced age nor uterine rupture was associated with postoperative death.

Table 1—Summary results for various outcomes and potential predictive variables of interest among 405 bitches that underwent ovariohysterectomy for treatment of pyometra between January 1, 2017, and December 31, 2019.

Variable	No. of bitches with status recorded	No. (%) of bitches with finding
Outcome		
Died prior to hospital discharge	405	11 (3)
Extended length of hospital stay (≥ 2 nights)	394	174 (44)
Ruptured uterus	390	11 (3)
Predictor		
Patient history		
Age > 8 y	404	184 (46)
Body weight < 8 kg	404	207 (51)
Duration of clinical signs > 1 wk	335	160 (48)
Previously evaluated by a veterinarian for the same episode of pyometra	404	228 (56)
Polyuria	385	192 (50)
Polydipsia	385	208 (54)
Diarrhea	376	135 (36)
Inappetence	391	349 (89)
Vomiting	383	190 (50)
Clinical signs		
Signs of depressed mentation	403	209 (52)
Closed pyometra	392	83 (21)
Nonambulatory	369	30 (8)
Increased respiratory effort	394	24 (6)
Tachypnea	376	307 (82)
Hypothermia	374	112 (30)
Febrile	374	79 (21)
Tachycardia	400	288 (72)
Dehydration	389	265 (68)
Laboratory findings on hospital intake		
Low PCV	399	138 (35)
Hypoglycemia	404	17 (4)
Hypercreatininemia	403	62 (15)
High BUN concentration	403	116 (29)
Comorbidities		
Mammary tumor	405	92 (23)
Heart disease	405	56 (14)
Heart murmur	405	54 (13)
Surgical findings		
Ascites	389	27 (7)
Transfusion	405	24 (6)

Percentages are rounded to the nearest whole percentage.

Results of multivariable analyses were compiled (**Table 2**). Surgically treated bitches with (vs without) a high BUN concentration or heart murmur had greater odds of dying before hospital discharge (OR, 4.72 and 4.14, respectively). The odds of remaining in the hospital ≥ 2 nights postoperatively were greater for bitches with ruptured uterus (OR, 24.11), inappetence (OR, 3.30), high concentrations of BUN (OR, 1.95), or serum creatinine (OR, 2.78), low PCV (OR, 1.87), or dehydration (OR, 1.77). Multivariable analyses that explored variables associated with uterine rupture did not yield any significant predictors. In all final models, the VIFs were < 3.3, which indicated covariates were not correlated with one another. Interactions were not significant in any of the models.

Predictive power and model fit

Although the presence of high BUN concentration or heart murmur was significantly ($P = 0.02$ and 0.03 , respectively) associated with death after OHE,

sensitivity was 0% for the model's predictions and indicated that the model was a poor predictor of postoperative death (Table 2). Of the 403 bitches with complete medical records, the model correctly predicted survival to hospital discharge for the 392 animals discharged and incorrectly predicted survival for the 11 animals that died in hospital, demonstrating this model's low sensitivity and concomitant poor positive predictive value. Three of the 11 bitches that died after OHE had high BUN concentrations or a heart murmur; however, 109 bitches with high BUN concentrations survived as well as 50 that had a heart murmur. Results for the Hosmer-Lemeshow χ^2 test of the model predicting death were not statistically significant, suggesting adequate model fit.

The logistic regression model for predictors of a length of hospital stay ≥ 2 nights correctly predicted an extended length of stay (≥ 2 nights) in the hospital after OHE for 95 of the 147 (65%) bitches that had an extended length of stay and correctly predicted a 1-night length of stay for 140 of the 197 (71%)

Table 2—Logistic regression models of association between variables of patient history, clinical signs, and laboratory findings and outcomes of postoperative death before hospital discharge (11/403 animals included in the analysis), extended length of hospital stay (≥ 2 nights; 152/344 animals included in the analysis), or euthanasia (22/424 animals included in the analysis).

Outcome/Variable	OR	SE	95% CI for OR	Wald statistic	P value	McFadden pseudo R^2	P value for Hosmer-Lemeshow χ^2 test	Sensitivity (%)	Specificity (%)
Died postoperatively						0.10	0.76	0.0	100.0
High BUN concentration	4.72	3.04	1.34–16.66	2.41	0.02				
Heart murmur	4.14	2.72	1.14–15.02	2.16	0.03				
Length of stay ≥ 2 nights						0.13	0.37	62.5	72.9
Ruptured uterus	24.11	27.11	2.66–218.45	2.83	0.01				
Inappetence	3.30	1.53	1.33–8.17	2.58	0.01				
Hypercreatininemia	2.78	1.21	1.18–6.53	2.34	0.02				
High BUN concentration	1.95	0.64	1.03–3.72	2.04	0.04				
Low PCV	1.87	0.47	1.14–30.6	2.48	0.01				
Dehydration	1.77	0.48	1.03–3.02	2.08	0.04				
Euthanasia						0.30	0.57	0.0	100.0
High BUN	6.45	5.95	1.06–39.30	2.02	0.04				
Hypercreatininemia	5.85	3.85	1.61–21.26	2.68	0.01				
Body weight < 8 kg	5.33	3.49	1.48–19.24	2.56	0.01				

bitches hospitalized for just 1 night. The results of the Hosmer-Lemeshow χ^2 test of the model predicting length of stay were not statistically significant, suggesting adequate model fit.

Bitches with pyometra not treated with OHE

Nineteen of 450 (4%) bitches with suspected pyometra were prescribed antimicrobials and analgesics for medical management, and 26 (6%) were euthanized. Of the 19 bitches treated medically, 16 were not eligible for surgery at the AAH due to the presence of serious comorbidities. Of these 16 animals not eligible for surgery at the AAH, 6 had notes in their medical records that also listed financial reasons for not pursuing treatment, 7 were referred to other hospitals for treatment, and 9 were prescribed medications and sent home for supportive care. Three of the 19 bitches medically treated did not have comorbidities but had owners who either were sent home with an application for financial assistance for the surgery and never returned ($n = 1$), declined the initial diagnostic procedures for a suspected pyometra (1), or chose to surrender their pet to another facility (1).

Of the 26 bitches euthanized, 11 (42%) were euthanized due to the presence of comorbidities not related to pyometra (including intervertebral disk disease [$n = 1$], mammary gland tumor (2), ulcerated mammary mass [1], renal disease [3], kidney failure [1], lymphoid leukemia [1], suspected neoplasia [1], and jaundice [1]), 11 (42%) were euthanized due to the severity of illness at presentation, and 2 (9%) were euthanized due to both severity of illness and presence of comorbidities (ulcerated mammary gland tumor [1] and kidney failure [1]). Additionally, 1 of the 26 (4%) was euthanized for financial reasons, and 1 (4%) was brought to the AAH for euthanasia

because of owner-reported poor quality of life, whereupon staff observed signs of pyometra.

Results were compared between those for the 26 bitches euthanized and those for the 405 that underwent OHE. The mean \pm SD age was significantly ($P = 0.05$) older for those euthanized (9 ± 3 years; range, 3 to 18 years) than for those that underwent OHE (8 ± 3 years; range, < 1 to 18 years). The median body weight was significantly ($P = 0.01$) lighter for those euthanized (5.1 kg, range, 1.9 to 26.6 kg; IQR, 3.6 to 7.0 kg) than for those that underwent OHE (7.8 kg; range, 1.3 to 59.0 kg; IQR, 4.4 to 22.0 kg). Results of exploratory univariable analyses of findings for patient history, clinical signs, serum biochemical analyses, and comorbidities for bitches with pyometra euthanized versus treated with OHE were compiled (**Supplementary Table 1**), and results of multivariable analysis (Table 2) indicated that bitches with (vs without) high concentration of BUN or serum creatinine at intake were 6.5 times as likely to have been euthanized, those with (vs without) high serum creatinine concentration at intake were 5.9 times as likely to have been euthanized, and bitches weighing < 8 kg (versus ≥ 8 kg) were 5.3 times as likely to be euthanized. No interactions in the euthanasia model were significant when evaluated with the likelihood-ratio test. Because of a potential relationship between variables for age and weight, we retested the final model with the inclusion of age (both as a continuous variable and as a binary variable [≤ 8 or > 8 years old]). Age was not a significant ($P = 0.53$) predictor of euthanasia when added to the final model nor did the inclusion of age change the other coefficient values.

High BUN concentrations

Bitches with high BUN concentrations (BUN > 26 mg/dL) at intake had greater odds of death after OHE (OR, 4.72), to have had an extended stay (≥ 2 nights) in the hospital (OR, 1.95), or to have been

euthanized (OR, 6.45). However, of the 116 bitches with pyometra treated with OHE that had high BUN concentration at intake, 109 (94%) survived to hospital discharge, and 40 of those 109 (37%) did not have an extended stay (≥ 2 nights) in the hospital after surgery. The mean BUN concentration was 71 mg/dL (range 37 to 108 mg/dL) for the 7 bitches with high BUN concentrations at intake and that died after OHE; however, 22 bitches that underwent OHE had BUN concentrations > 71 mg/dL (some had BUN concentrations as high as 141 mg/dL) and survived to hospital discharge.

Discussion

Associations between various clinical signs or laboratory findings and various surgical outcomes can help to inform treatment decisions. We found a 3% (11/405) mortality rate for surgically treated bitches with pyometra, which was a finding slightly, but not statistically significantly, higher than the 1% (4/315; 95% CI, 0.3 to 3%) reported by Jitpean et al.⁹ The proportion of surgically treated bitches hospitalized ≥ 2 nights was 44% (174/394). We also found that 3% (11/390) bitches with pyometra had a ruptured uterus.

We found that the presence of high BUN concentration or heart murmur was associated with greater odds of death after OHE; however, those variables were poor predictors and did not lead to a high likelihood of death. Variables associated with an extended length of hospital stay included uterine rupture, inappetence, high concentrations of BUN or serum creatinine, low PCV, and dehydration, alone or in combination. Although we could not identify significant predictors of uterine rupture, Jitpean et al.⁹ had identified leukopenia as a predictor of uterine rupture, which we could not affirm because preoperative CBCs were not routinely completed for dogs of the present study.

We also found that small bitches (< 8 kg) that had high concentrations of BUN or serum creatinine had greater odds of have been euthanized instead of treated with OHE. Because the AAH treatment guidelines precluded surgical treatment for animals with poor prognoses, and high concentrations of BUN or serum creatinine were initially considered to have been indicators of poor prognosis, animals with such findings during the early months of the study period may have been more likely to have been euthanized because of their test results. Older age was considered to have a poor prognosis; indeed, euthanized bitches were significantly older than those that underwent OHE in the present study. Because smaller dogs live longer than large dogs,²¹ we suspected this was the reason smaller bitches were more likely to have been euthanized.

Although bitches with high BUN concentrations had greater odds of death in the present study, the predictive power of these results was relatively weak. Many bitches with high BUN concentrations were successfully treated with OHE at the AAH, a finding that suggested that even bitches with high BUN

concentrations could be treated with OHE and basic care in general practice settings. Likewise, because inappetence, high serum creatinine concentration, high BUN concentration, low PCV, and dehydration were associated with a length of stay ≥ 2 nights, veterinarians could use this information to decide whether they can support this extended hospitalization postoperatively.

Interestingly, many conditions that would typically be expected to significantly increase odds of death did not; findings indicated that bitches with pyometra recover after OHE even when initially quite ill. The likelihood of postoperative death did not differ for bitches that required versus did not require a transfusion, and neither advanced age nor uterine rupture was associated with postoperative death. Jitpean et al.⁹ reported a 100% rate of survival to hospital discharge for the 8 bitches with ruptured uterus among 315 bitches with pyometra.⁹ Although bitches have been reported to be more severely ill with closed-cervix pyometra and more vulnerable to sepsis,^{3,22} that the cervix was open or closed did not significantly influence mortality rates or length of hospital stay in the present study. Similarly, Jitpean et al.²³ reported no poorer outcomes associated with closed-cervix pyometra.

Our results suggested that OHE for pyometra may be slightly delayed for many bitches without detrimental effects on outcomes; therefore, clients that cannot afford immediate treatment for pyometra in an emergent setting may be able to wait and schedule a more affordable surgery the following day. Bitches that had clinical signs for more than 1 week prior to arriving at the AAH were not significantly more likely to die after OHE, have an extended length of stay, have a ruptured uterus, receive a transfusion, or be euthanized. This was also the case for 228 bitches that had been seen previously by a different veterinarian and subsequently referred to AAH for treatment. Even patients with closed pyometra that had a duration of clinical signs > 1 week or were taken to a veterinarian prior were not more likely to have died after OHE, compared with patients with closed pyometra and a duration of clinical signs < 1 week or that had not been seen by a veterinarian prior to arriving at the AAH.

The cases included in the present study had similar signalments as those described elsewhere.^{3,5,14} However, the AAH specifically targeted the underserved pet-owning population of New York City, providing care to pets of individuals with limited access to veterinary care due to transportation or financial limitations or other barriers. Most (230/405 [57%]) bitches that underwent OHE for pyometra at the AAH had been seen by a veterinarian prior to arriving at the AAH, and in many cases, pet owners who initially took their pet to another practice were subsequently referred to the AAH due to owner's financial constraints. Therefore, our sample may have had a longer duration of clinical signs, compared with those with standard access to veterinary services.

A limitation of the present study was that some pertinent information was not collected when the

animals were treated or was not documented in the medical records. For instance, CBCs were not conducted on most of the cases in the sample; therefore, we could not investigate the role of potentially important parameters such as WBC count. Because the AAH did not perform bacterial culture or otherwise evaluate samples of uterine fluid, the bitches in the present study may not have consisted of exclusively those with pyometra but could have included those with hydrometra or mucometra. In some cases, information was missing from the medical records for key clinical findings. For instance, nonambulation and abnormal rectal temperature and respiratory rate are potentially important predictors of pyometra outcomes, and it was possible that missing data influenced the predictive power of these variables in the models. We believe that it was for these reasons that multivariable analyses to identify variables associated with a uterine rupture did not yield significant predictors; in this model, data were missing for several potentially key variables, such as respiratory rate, which was high in all 8 bitches with uterine rupture and respiratory rate documented in the medical record.

Readily available indicators based on findings from physical examination, patient history, or simple bloodwork that helped predict pyometra outcomes could enable general practice veterinarians to make informed decisions about which cases may be appropriate for treatment in their practices versus may require more intensive treatment in a specialty practice setting. Our findings refuted the common belief that pyometra must be treated on an emergency basis, as many of the patients in the present study had either been seen previously at other veterinary clinics or had a protracted duration of clinical signs. Although results of the present study identified variables that could increase odds of death and greater length of hospital stay, these indicators were poor predictors. Our data demonstrated that most bitches, even with apparently high-risk presentations of serious illness, survived to hospital discharge after OHE was performed in a general, nonspecialty hospital with high-quality basic supportive care. Even without highly specialized treatments, such as plasma transfusions, dialysis, and the use of Jackson-Pratt drains, bitches that underwent OHE for pyometra had a 97% (394/405) rate of survival to hospital discharge. As such, most general practitioners that offer OHE could expect to see similar outcomes.

Knowledge of potential outcomes of OHE for pyometra in bitches helps veterinarians' decisions in case management and collaborative treatment decisions between veterinarians and clients because veterinarians can comprehensively communicate treatment options, risks, and costs. We believe that the availability of OHE for pyometra in bitches could improve if more veterinarians in general practice become more comfortable treating pyometra in their clinics and communicating treatment options with clients; thus, more lives of affected pets could be saved.

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References

1. Jitpean S, Hagman R, Ström Holst B, Höglund OV, Pettersson A, Egenvall A. Breed variations in the incidence of pyometra and mammary tumours in Swedish dogs. *Reprod Domest Anim.* 2012;47(Suppl 6):347–350.
2. Fransson BA, Ragle CA. Canine pyometra: an update on pathogenesis and treatment. *Compendium.* 2003;25(8):602–612.
3. Hagman R. Pyometra in small animals. *Vet Clin North Am Small Anim Pract.* 2018;48(4):639–661.
4. Hagman R. Clinical and molecular characteristics of pyometra in female dogs. *Reprod Domest Anim.* 2012;47(Suppl 6):323–325.
5. Prasad VD, Kumar PR, Sreenu M. Pyometra in bitches: a review of literature. *Res Rev J Vet Sci Tech.* 2017;6(2):12–20.
6. Davidson J, Black D. Small animal pyometra. In: Aronson LR, ed. *Small Animal Surgical Emergencies.* 1st ed. Wiley; 2016:397–402.
7. Pratschke K. Pyometra. In: Griffon D, Hamaide A, eds. *Complications in Small Animal Surgery.* John Wiley & Sons, Inc.; 2016:517–521.
8. Hagman R, Kindahl H, Fransson BA, Bergström A, Holst BS, Lagerstedt AS. Differentiation between pyometra and cystic endometrial hyperplasia/mucometra in bitches by prostaglandin F_{2α} metabolite analysis. *Theriogenology.* 2006;66(2):198–206.
9. Jitpean S, Ström-Holst B, Emanuelson U, et al. Outcome of pyometra in female dogs and predictors of peritonitis and prolonged postoperative hospitalization in surgically treated cases. *BMC Vet Res.* 2014;10(1):6.
10. Baithalu R, Maharana BR, Mishra C. Canine pyometra. *Vet World.* 2010;3(7):340–342.
11. Bartoskova A, Vitasek R, Leva L, Faldyna M. Hysterectomy leads to fast improvement of haematological and immunological parameters in bitches with pyometra. *J Small Anim Pract.* 2007;48(10):564–568.
12. McCallin AJ, Hough VA, Kreisler RE. Pyometra management practices in the high quality, high volume spay-neuter environment. *Top Companion Anim Med.* 2021;42:100499.
13. Farquhar RG. Canine pyometra: assessment to optimise outcomes in first-opinion practice. *Companion Anim.* 2017;22(3):126–131.
14. Hagman R. Diagnostic and prognostic markers for uterine diseases in dogs. *Reprod Domest Anim.* 2014;49(Suppl 2):16–20.
15. Küplülü S, Vural MR, Demirel A, Polat M, Akçay A. The comparative evaluation of serum biochemical, haematological, bacteriological and clinical findings of dead and recovered bitches with pyometra in the postoperative process. *Acta Vet Brno.* 2009;59(2–3):193–204.
16. Sant'anna MC, Giordano LGP, Flaiban KKM, Muller EE, Martins MIM. Prognostic markers of canine pyometra. *Arq Bras Med Vet Zootec.* 2014;66(6):1711–1717.
17. Hauptman JG, Walshaw R, Olivier NB. Evaluation of the sensitivity and specificity of diagnostic criteria for sepsis in dogs. *Vet Surg.* 1997;26(5):393–397.
18. Zoetis. *i-STAT Alinity v Utilization Guide.* Parsippany, NJ, Zoetis Services LLC; 2019.
19. Pailler S, Slater M, Lesnikowski S, et al. Findings and prognostic indicators of outcomes for queens with pyometra

- treated surgically in a nonspecialized setting. *J Am Vet Med Assoc.* 2022;260(S2):S42-S48.
20. Pailler S, Dolan ED, Slater MR, Gayle JM, Lesnikowski SM, DeClementi C. Owner-reported long-term outcomes, quality of life, and longevity after hospital discharge following surgical treatment of pyometra in bitches and queens. *J Am Vet Med Assoc.* 2022;260(S2):S49-S56.
 21. O'Neill DG, Church DB, McGreevy PD, Thomson PC, Brodbelt DC. Longevity and mortality of owned dogs in England. *Vet J.* 2013;198(3):638-643.
 22. Smith FO. Canine pyometra. *Theriogenology.* 2006; 66(3):610-612.
 23. Jitpean S, Ambrosen A, Emanuelson U, Hagman R. Closed cervix is associated with more severe illness in dogs with pyometra. *BMC Vet Res.* 2017;13(1):11.

Supplementary Materials

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