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Ultrasound-Guided Cystocentesis in Dogs and Cats - Epidemiological Study of Risk Factors and Complications*

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ABSTRACT

***Background*:** Cystocentesis is a percutaneous aspiration of urine directly from the urinary bladder. It is a routine procedure in veterinary medicine for laboratory urine evaluation and bladder decompression in dogs and cats. Although considered simple and causing minimal discomfort, it remains invasive with potential risks of complications. These complications include bladder rupture leading to abdominal contamination and peritonitis, as well as aortic and vena cava laceration, abdominal wall injuries, seizures, and syncope. There is a scarcity of epidemiological studies assessing risk factors and associated complications and, in this context, we aimed in this study to correlate risk factors with the main complications of ultrasound-guided cystocentesis in dogs and cats.

***Materials, Methods & Results*:** It was a prospective and multicentric study involving 410 animals (267 dogs and 143 cats) with clinical indications for cystocentesis. The animals were positioned in dorsal recumbency and restrained by either owner, technical staff, or both. Temperament (calm/docile or agitated/difficult to restrain), along with various data such as species, breed, weight, age, sex, needle length, number of attempts, volume of urine collected, ultrasound findings, and any complications during the procedure, were recorded. Animals were categorized into 2 groups, group with complications (GCI) and group without complications (GSI). Of these, 31 animals (8%) experienced complications after ultrasound-guided urine collection. Compared to agitated animals, there was an 86% reduction in the likelihood of complications in animals classified as calm and easy to handle. Repeated urine collection attempts increased the chance of complications by 110%, even in calm individuals, and each additional millimeter of needle length used for puncture increased the possibility of complications by 30%. Agitated animals restrained by their owner had a 71% chance of complications compared to 7% when they were restrained by the technical staff.

***Discussion*:** The data reveals a low probability of complications (8%) during cystocentesis, but it is crucial to consider the risk factors for each patient, as catastrophic outcomes can occur. Interestingly, older animals had a 14% lower likelihood of complications, likely due to increased adaptability and calmness. Proper restraint by a specialized team significantly reduced complication risks, even for agitated animals, which is a noteworthy finding not previously reported. Repeated attempts at urine collection increased complication risks, as did using longer needles, which could damage tissues and puncture vessels near the bladder. In this study, data regarding bladder filling was not included, potentially impacting the results and procedure difficulty. The absence of behavioral assessment scales to measure agitation or anxiety resulted in subjective assessments, lacking standardization. Ultrasound guidance during cystocentesis is valuable to minimize risks and should be considered. While the probability of complications is low, owners should be informed of potential risks, and sedation may be necessary for very agitated or uncooperative animals. In conclusion, ultrasound-guided cystocentesis resulted in complications in approximately 8% of cases. These complications can be significant, such as puncturing large vessels and rupturing the urinary bladder.

Keywords: cystocentesis, ultrasound, canine, feline, complication, epidemiology.

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INTRODUCTION

Cystocentesis is defined as the percutaneous aspiration of urine directly from the urinary bladder [9,20]. This technique is used for obtaining uncontaminated urine samples or for bladder decompression in patients unable to urinate or with urethral obstruction [5]. Cystocentesis, both in dogs and cats, is a routine procedure in veterinary medicine for laboratory evaluation of urine in urinary tract disease and for bladder decompression [5,10,12,14,16,17]. However, although it is general considered a simple procedure that causes little pain and/or discomfort, it is an invasive procedure with potential risks of complications [4,5,11,12,16,17].

Cystocentesis is specifically contraindicated in animals that are difficult to restrain, or when there is an empty urinary bladder, history of abdominal trauma, recent surgery, pyometra, coagulopathy, or ongoing use of anticoagulants [1,5,12,16,17]. In addition, patients with urinary bladder cancer or non-delimited abdominal cancer are not candidates for the procedure, and other means of urine collection or bladder decompression are preferred in these cases [11,20].

Complications related to cystocentesis, although uncommon, have been described in dogs and cats. These include bladder rupture, with consequent abdominal contamination and peritonitis [11,17], aortic and vena cava laceration [1], abdominal wall injuries, seizures, and syncope [12]. However, despite severe complications related to the technique, epidemiological studies assessing risk factors [11] and associated complications [10] are scarce. Therefore, this study aimed to correlate risk factors with the main complications of ultrasound-guided cystocentesis in dogs and cats.

MATERIALS AND METHODS

Animals

It was a prospective and multicentric study, enrolling routine hospital patients, of 4 imaging diagnostic centers in the country, from July 2021 to July 2022. All animals in the study had clinical indications for ultrasound-guided cystocentesis for urine collection or bladder emptying.

Experimental design

The animals were admitted to the diagnostic imaging service for ultrasound-guided cystocentesis. The cystocentesis procedure was carried out by veterinarians experienced in imaging and trained in cystocentesis, using ultrasonographic phantoms for at least six months before the beginning of the study. All animals were positioned in dorsal recumbency, on a foam positioning cushion for ultrasonography, and restrained by the pelvic and thoracic limbs with the help of two individuals. Individuals involved in the restraint could be owners and technical staff, only technical staff, or only owners. The imaging specialist who performed the procedure subjectively classified each animal’s temperament as either: calm/docile or agitated/difficult to restrain, according to the ease of restraint and positioning of the animal at the time of collection.

Data regarding species, breed, weight, age, sex, needle length, number of attempts, volume of urine collected, and presence of bladder abnormalities seen on ultrasound examination were collected. Needles with lengths of 20, 25, and 30 mm were included in this study. In addition to information on the collection procedure, the sonographic findings were recorded along with their respective differential diagnoses. The findings were classified according to Sutherland-Smith and Penninck (2015) [18] as: 1) cystitis, when "the bladder wall was diffusely thickened, with mild to moderate thickening, or with focal cranioventral thickening, and the mucosa slightly irregular and the wall hypoechoic"; 2) presence of uroliths, "one or more hyperechoic structures producing acoustic shadowing, intraluminal and mobile, of different sizes were identified"; 3) intraluminal clots, when "the presence of linear or rounded structures, with variable echogenicity were observed"; or 4) obstruction or bladder distention, when "accumulation of large amounts of anechoic content within the urinary bladder was observed". All abnormalities were correlated with the patient's clinical and laboratory findings for final classification.

Data regarding accidental venous or arterial punctures, enteric punctures, punctures of cysts or lymph nodes, skin or muscle lesions, the presence of syncope or convulsions during collection, were recorded. Details of who restrained the animal were recorded. Moreover, the clinical repercussions of the complications listed and the need for surgical or conservative intervention were recorded. At the end of each procedure, data were recorded in a single questionnaire, delivered in print or remotely through the google forms platform, according to the preference of the investigator. After data collection, the animals were divided into 2 groups; with complications (GCI) and without complications (GSI).

Statistical analysis

The Shapiro-Wilk test was used to verify the normality of the numerical data distribution. Parameters with normal distribution are presented as mean ± standard deviation of the mean. Parameters with non-normal distribution are presented as median (minimum-maximum). Results with normal distribution were submitted to Student's t test for comparison within the different groups. Results with non-normal distribution were submitted to the Mann-Whitney Rank Sum test for comparison between the different groups.

The predictor variables were submitted to logistic regression analysis to determine the chance of these variables causing an intercurrence. For this analysis, the Stepwise technique was used for an additional selection of the predictor variables with the best results. At this point, the predictor variables were removed and added one by one using the t-test. Additionally, a decision tree was built to determine the probability of the collected data influencing the presence of intercurrences during the procedure.

McFadden's pseudo R2 value greater than 0.4 was used to assess the quality of the model, in addition to accuracy, sensitivity, and specificity. Significance level was set at 5% ($P < 0.05$). All tests were performed using the R statistical analysis program for Windows 12.0[1].

RESULTS

Data were collected from 410 animals undergoing ultrasound-guided cystocentesis. This included 267 dogs (174 females and 93 males) and 143 cats (57 females and 86 males).

The average weight of the animals was 9.54 ± 8.82 kg and mean age was 8.61 ± 4.52 years. The average number of attempts and the volume of urine obtained were 1.42 ± 0.74 times and 7.5 ± 4.5 mL, respectively. There were no significant differences between the weight of the animals ($P = 0.478$) and the amount of urine collected ($P = 0.224$) between groups. However, the age in the GSI was significantly higher ($P = 0.033$) compared to the GCI, and the number of attempts in the GCI was significantly higher ($P < 0.001$) compared to GSI. When comparing dogs and cats, only the weight of the dogs was significantly higher ($P < 0.001$).

Data regarding weight, age, sex, number of attempts, and amount of urine collected are shown in Table 1.

Of the animals included in the study, 57 (13.90%) had cystitis, 12 (2.92%) had a combination of cystitis and urolithiasis, and 11 (2.68%) had signs of obstruction with a full urinary bladder. Uroliths were found in 16 (3.90%) animals, 1 (0.24%) presented with intraluminal clots, and, in 313 (76.34%) animals, no ultrasonographic alterations of the urinary bladder were observed. The distribution and frequency of ultrasound changes in the urinary bladder in both groups are shown in Table 2.

Regarding behavior, 196 (47.80%) animals were considered agitated and difficult to restrain, and 214 (52.20%) were considered calm. In 361 (88.04%) animals, the restraint was performed by the technical staff, in 37 individuals (9.02%) by the staff and the owner, and in 12 animals (2.92%) only by the owner.

There were 32 complications in 31 animals (7.56%), of which 22 (70.96%) were dogs, and 9 (29.03%) were cats. The main complications found were: subcutaneous hematoma (46.87% - 15/32), accidental blood vessel punctures (46.87% - 15/32), syncope (3.12% - 1/32) and bladder rupture (3.12% - 1/32). One animal had an aortic puncture followed by syncope.

After the initial evaluation, species, weight, sex, and volume of urine collected were removed from the logistic regression model because they did not show predictive power for the occurrence of any intercurrence. The model showed a McFadden pseudo R2 value of 0.422 ($P < 0.001$). In addition, the model had an accuracy of 94.8%, a sensitivity of 98.9%, and a specificity of 45.1%. The model is shown in Table 3, and the effects of sensitivity and specificity in the regression model are graphically shown in Figure 1.

The model suggests that as age increases there is a reduction (14%) in the risk of complications. Moreover, there was a decrease (86%) in complications in calm and easy-to-handle animals compared to agitated and/or difficult-to-restrain animals. If a specialized team handles agitated animals, there is a further reduction in the chances of complications (80%).

Additionally, it was observed that repeated attempts to perform the procedure increased the chance of complication by 110%, even in calm animals. Also, with each extra millimeter of needle length, the possibility of complication increased by 30%.

Table 1. Data regarding weight, age, number of attempts, and amount of urine collected in patients undergoing ultrasound-guided cystocentesis.

	Weight (kg)	Age (years)	Number of attempts	Amount of urine (mL)	Sex		Temperament	
					Female	Male	Agitated	Calm
Dogs	12.37 ± 9.77*	8.73 ± 4.14	1.41 ± 0.71	7.98 ± 4.11	174	93	80	187
Cats	4.26 ± 1.57	8.44 ± 5.15	1.44 ± 0.79	6.61 ± 5.13	57	86	116	27
GCI	10.67 ± 9.77	6.66 ± 4.82	1.93 ± 0.96#	8.16 ± 10.08	13	18	24	7
GSI	9.44 ± 8.75	8.78 ± 4.46#	1.38 ± 0.7	7.46 ± 3.76	218	161	172	207

GSI: group without complications; GCI: group with complications; *species with a numerical value significantly higher; #group with significantly higher numerical value; normal parameters presented as mean ± standard deviation of the mean; non-normal parameters presented as median (maximum-minimum).

Table 2. Sonographic changes found during the evaluation of the animals included in the study, their distribution, and frequencies within each group of animals.

	Cystitis*	Cystitis + urolithiasis	Obstruction + full urinary bladder	Urolithiasis	Intraluminal clots	No changes	Total
GSI	46 (12.13%)	10 (2.63%)	9 (2.37%)	16 (2.37%)	1 (0.26)	297 (78.36)	379 (100%)
GCI	11 (35.48%)	2 (6.45%)	2 (6.45%)	0 (0%)	0 (0%)	16 (51.61%)	31 (100%)
Total	57 (13.90%)	12 (2.92%)	11 (2.68%)	16 (2.43%)	1 (0.24%)	313 (76.34%)	410 (100%)

GSI: group without complications; GCI: group with complications; *group with significantly higher frequency.

Table 3. Results of the logistic regression model (Stepwise technique) for complications in dogs and cats submitted to ultrasound-guided cystocentesis, according to age, calm temperament, restraint performed by the technical team, number of attempts, and needle length.

Variable	Estimated	Standard error	OR	Z value	*P*
Intercept	-7.038	2.618	0.001	-2.689	0.007
Weight (kg)*	-0.037	0.027	0.964	-1.358	0.174
Age (years)	-0.153	0.059	0.858	-2.598	0.009
Temperament – Calm/easy restraint	-1.945	0.531	0.143	-3.666	0.000
Restraint - Technical team	-1.591	0.595	0.204	-2.675	0.007
Restraint - Owner*	1.631	0.944	5.108	1.728	0.084
Number of attempts	0.740	0.279	2.096	2.648	0.008
Needle length (mm)	0.263	0.093	1.301	2.836	0.005
Bladder changes on ultrasound *	0.732	0.498	2.080	1.472	0.141

*Variables without significance were kept in the model, as they interfered with the predictive value of the other variables.

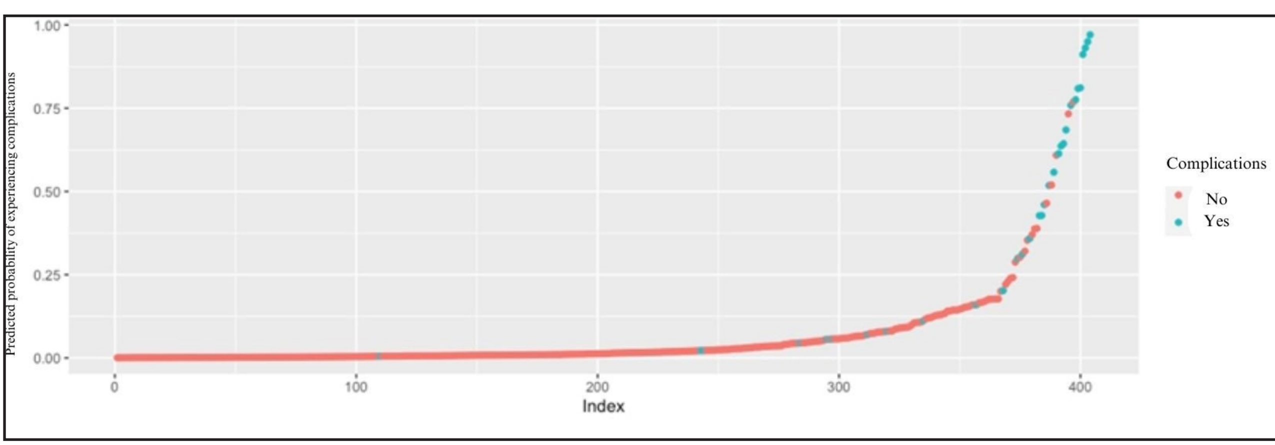

Figure 1. Scatter plot showing the probability of intercurrence estimated by the logistic regression model and the intercurrences that actually occurred in 410 animals evaluated after the ultrasound-guided cystocentesis procedure.

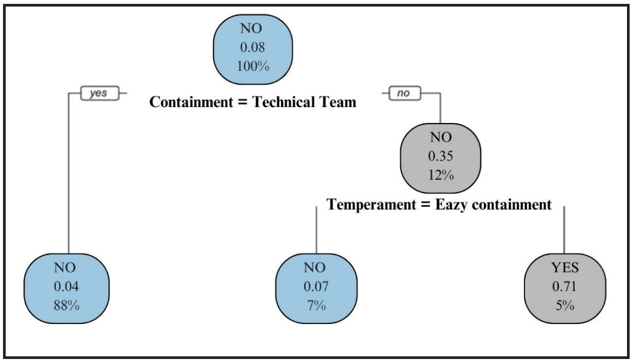

Figure 2. Decision tree constructed with temperament and restraint data from the animals evaluated after the ultrasound-guided cystocentesis procedure.

The main predictor variables for the decision tree were patient temperament and the type of restraint used for the procedure. This model had an accuracy of 94.6%, a sensitivity of 98.4%, and a specificity of 48.5%.

In this study there was an 8% probability of complication. The first node of the decision tree shows a reduction of 4% when the technical team carried out the restraint and an increase of 35% when restraint was performed by the owners. Moreover, when restrained exclusively by the owners, calm patients had a 7% probability of complication, while agitated animals had 71%. These results are shown in Figure 2.

One of the animals that had aorta or vena cava puncture developed syncope during the procedure. This animal was the only one to suffer hemodynamic repercussions, with an accumulation of free fluid after the procedure, and volume replacement and abdominal packing was required for stabilization and hemostasis. A 2nd animal developed free fluid accumulation after an accidental puncture of an intra-abdominal blood vessel, but without hemodynamic repercussions.

One cat suffered bladder rupture after relief cystocentesis. Laboratory analysis of the free fluid showed a creatinine value of 13 g/dL. After diagnosis, the animal was referred for exploratory laparotomy and surgical correction of the laceration. No animal died as a result of cystocentesis.

DISCUSSION

This study presents a prospective analysis describing the risk factors associated with complications of ultrasound-guided cystocentesis in dogs and cats. The data show that, although the probability of complications is low (8%), there is the possibility of catastrophic outcomes that can be fatal. It is therefore important to consider all the risk factors for the individual patient when cystocentesis is indicated. The low probability for complications was reflected in the specificity of the logistic regression model and the construction of the decision tree.

In this study, it was found that with each additional year of life in these animals, there was a 14% reduction in the likelihood of experiencing a complication. We believe that as the animals age, they become more accustomed to physical restraint and also become calmer and more disciplined. This factor may have influenced the incidence of complications in this study.

Animals restrained by a specialized team had a significant reduction in the risk of complications, even when agitated and difficult to handle. This has not previously been reported in the literature and highlights the importance of appropriate restraint by a trained team. In addition, repeated attempts to collect urine by cystocentesis significantly increased the risk of complications, as has been described previously [1].

A single study reporting complication related to ultrasound-guided cystocentesis in dogs and cats has been published. The authors retrospectively described the adverse effects of urine collection by cystocentesis in 21 animals and classified them as major or minor according to the severity of the event [10]. These animals were screened from a large group of animals (around 26,000), clearly showing that the probability of a complication after cystocentesis is small, but potentially dangerous. Our study and the previously published study are similar, but not directly comparable, mainly due to differences in data collection. Retrospective studies may not accurately represent reality, as the collection of information relies on proper registration.

Accidental punctures of large vessels and subcutaneous hematomas were the most frequent complications in this study, with 15 animals in each. The complication profile described by Manfredi et al. [10] was similar to that found in our research. In addition to the potential for severe complications, such as iatrogenic laceration of large vessels, septic peritonitis, and acute abdomen; minor complications have also been described, such as fat necrosis, abscesses, intravesical hemorrhage and hematoma, urinary bladder rupture, focal peritonitis, subcutaneous and cutaneous hematomas, urinary sediments and intravesical mucosal edema.

In the present study, accidental puncture of a large vessel occurred in two animals. They both presented with free fluid in the abdomen and the formation of a clot dorsal to the urinary bladder. One of these animals had hemodynamic repercussions associated with hemorrhage, but blood transfusion/ surgery was not required. This animal's condition improved after fluid therapy for volume replacement and packing for hemostasis. Immediate identification of the complication using ultrasound follow-up to visualize blood extravasation and clot formation, and serial follow-up examinations were able to reduce the morbidity and potential mortality risk in these animals.

Accidental punctures of large vessels during cystocentesis has previously been reported on 2 occasions [1,10]. In the 1st report, the dog had active hemorrhage secondary to cystocentesis which resolved after a massive blood transfusion and surgical correction of the laceration. This dog had been physically restrained and classified as agitated. In addition, 3 attempts at cystocentesis were made before a urine sample was collected, and the procedure was performed without ultrasound guidance [1]. Both our patient with hemodynamic instability, and the patient reported by Buckley *et al*. [1], were classified as agitated and uncooperative, and the complication was observed after repeated attempts to perform the collection. These results suggest that agitated animals must be adequately restrained, including the use of sedation where necessary, and that repeated collection attempts may significantly increase the risk of complications. A 2nd study reported that two animals suffered focal hemorrhage without hemodynamic repercussions and the need for clinical or surgical interventions [10], similar to the other animals in our study that had accidental punctures of the vena cava or abdominal aorta.

One of the dogs included in this study, in which an accidental puncture of the aorta occurred, suffered syncope shortly after cystocentesis. This event has been previously reported in a cat [12] related to the excessive parasympathetic activity by vasovagal stimulation during the stressful event of abdominal puncture [6,12,19]. This type of vagal response has also been described in human patients and is characterized by a combination of bradycardia and arterial vasodilation [6,13,19].

The vasovagal reflex can develop due to relative or absolute blood loss. However, it can also occur due to intense emotions and mechanical stimulation of the vagal nerve, as seen in vascular punctures or cystocentesis [6]. In mammals, the vagal nerve is responsible for the parasympathetic innervation of all viscera, abdominal and thoracic, including the urinary bladder, making its stimulation an additional risk for the activation of the vasovagal reflex [3,6,12]. The syncope seen in our patient could be related to the accidental aortic puncture and subsequent hemorrhage, as well as to the vagal stimulation caused by the puncture of the urinary bladder.

In this study, 1 cat was diagnosed with uroabdomen due to a urinary bladder rupture after relief cystocentesis. In cats with urethral obstruction, the combination of bladder distention and increased intra-abdominal pressure can lead to severe pain, and electrolyte and hemodynamic decompensation [2,8,15]. Relief cystocentesis in these animals is currently indicated as emergency therapy until urethral flow is reestablished, accepting the risk of bladder rupture and uroabdomen. Urethral obstruction and electrolyte imbalances offer a greater risk to the patient's life than uroabdomen and its resolution [2,4,5,8, 10,15]. Furthermore, there is a risk of bladder rupture or damage to the urinary bladder wall, leading to uroabdomen after cystocentesis [9,10,15]. The animal in this study recovered completely after surgical correction of the bladder rupture and relief of the urethral obstruction, as previously reported in the literature [7,8,10,15].

In addition, there was a 30% increase in the likelihood of complications for each additional mm needle length used for the procedure. Longer needles may damage the tissues and puncture vessels in dorsal to the urinary bladder. Ultrasound-guidance is therefore very useful in cystocentesis to monitor needle placement and selection of an appropriate length of needle urine collection will reduce the risk of damage dorsal to the bladder. Although cystocentesis has been described without the use of ultrasound, this technique is not recommended due to the associated risks and difficulty in assessing damage after the procedure [1,4,9,10,16]. Our results reinforce the need to monitor the patient with ultrasound after the procedure.

In this study, data regarding bladder filling was not included. Therefore, empty or very distended urinary bladders may have influenced the results and/ or the difficulty of performing the procedure. Furthermore, behavioral assessment scales were not used to determine levels of agitation or anxiety, and subjective assessment was made which was not standardized.

Ultrasound-guided cystocentesis is invasive and the potential risks must be considered and explained to the owners, although probability of complications is low. In addition, the risk of complications is significantly reduced if the animal is restrained by a trained team, and sedation should be considered in very agitated or uncooperative animals.

CONCLUSION

In conclusion, complications were seen in around 8% of ultrasound-guided cystocentesis. Complications of the procedure can be significant, including the puncture of large vessels and the rupture of the urinary bladder. In addition, complications are more common in agitated animals and in animals restrained by owners.

MANUFACTURER

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***Ethical approval*.** The study was submitted to, and approved by, the Animal Ethics Committee of the Agricultural Sciences sector of the Federal University of Paraná - CEUA/AG-UFPR (009/2021).

***Declaration of interest*.** The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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