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Risk factors, complications, and outcomes of cystotomy in guinea pigs: 25 cases (2010–2023)

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OBJECTIVE
To describe the complications, surgical outcome, and prognosis associated with cystotomies in guinea pigs.

METHODS
A retrospective review of medical records of guinea pigs undergoing cystotomy for uroliths or urethroliths between 2010 and 2023.

RESULTS
25 guinea pigs were included in the study. Uroliths were confirmed on radiographs in all 25 cases, with 9 patients (36%) having at least 1 stone within the urethra. The cystotomy procedure was associated with an intraoperative complication rate of 24% and a short-term complication rate of 76%. Discomfort was the only presenting clinical sign significantly associated with survival, with a risk of dying prior to discharge that was a sixth of the risk of dying if a patient presented without signs of discomfort (risk ratio = 0.177). For patients with a stone within the urethra, the probability of death prior to discharge was 6 times that of patients with a stone within the bladder (P = .010; risk ratio = 5.966).

CONCLUSIONS
Cystotomies were associated with a mortality rate of 40% prior to discharge and 56% within the first month postoperatively. Further studies are needed to determine what specifically may lead to the high mortality rate as well as whether alternative minimally invasive procedures may be helpful in improving outcomes.

CLINICAL RELEVANCE
This study is the first to document risk factors, complications, and outcomes of a cohort of guinea pigs specifically undergoing cystotomy for urolithiasis. Given the high risk for complications and mortality, caution and owner preparation must be considered when a cystotomy is recommended for guinea pig patients.

Keywords: cystotomy, guinea pig, urolithiasis, urinary obstruction, risks

Urinary disease, including cystitis, urolithiasis, and tumors of the bladder wall, is a common finding in guinea pigs. Of the urinary conditions, urolithiasis is frequently diagnosed in domestic guinea pigs.[1–8] The composition of guinea pig uroliths is primarily calcium carbonate, although calcium oxalate and struvite uroliths have also been identified. The formation of urolithiasis is presumed to be associated with an inappropriate diet and inadequate water intake. Diets consisting of high-calcium foods such as alfalfa hay may contribute to their formation.[1–5,7,8] Urolithiasis is even more common in guinea pigs than other mammals because guinea pigs mainly excrete calcium through their urine.[1,3] Thus, they are more prone to producing calcium-containing stones due to the high concentration of calcium within their urine. In addition, guinea pig urine tends to be more alkaline, which can predispose them to stone formation.[3,7]

Guinea pigs with urolithiasis can present with a range of clinical signs from being asymptomatic to being obtunded. Common clinical signs observed by owners include hematuria, stranguria, and vocalization. Often owners may misinterpret stranguria as constipation. Other reported clinical signs that may indicate pain and discomfort include teeth grinding, a hunched posture, and vocalizing while urinating.[2–5,7] The severity of clinical signs worsens if a guinea pig develops a urinary obstruction secondary to its urolithiasis, particularly if an obstruction is prolonged.[9]

Due to the composition of most uroliths in guinea pigs, the diagnosis of urolithiasis is typically made

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based on radiographic imaging.[2–5] These uroliths can be located anywhere along the urinary tract, from the kidney to the urethra, but are most typically found within the urinary bladder or proximal urethra.[2,4,5] Stones can also be found within the seminal vesicles of male guinea pigs.[2,7]

The choice of treatment depends on several factors, including the size and location of the urolith, the patient's clinical status, and the owner's financial constraints. Surgery is considered the treatment of choice for large or painful stones.[7] If uroliths are present within the urethra, they may be flushed back into the bladder or removed via a urethrostomy.[2] Medical management may be considered for smaller stones (< 5 mm) or in cases where surgery is not possible.[2] Conservative treatment typically includes analgesia, antibiotics, reducing consumption of calcium-rich foods, and frequent monitoring with periodic radiographs and urinalyses.[2]

There is a paucity of information regarding the risk factors, complications, and short-term outcomes associated with guinea pig cystotomies. A recent retrospective study[2] including 158 guinea pigs with urolithiasis found that 54.4% of guinea pigs undergoing both medical and surgical management survived to discharge. Risk factors found to increase mortality included male sex, older age, presenting complaints including anorexia and weight loss, and lower rectal temperature on presentation. Surgical intervention was not found to be a risk factor, but the overall survival rate for patients undergoing cystotomy was not discussed.[2]

The aim of this study was to describe the risk factors, complications, and short-term outcomes for guinea pigs specifically undergoing a cystotomy for urolithiasis. Based on the findings of Edell et al,[2] our hypothesis was that older patients, male guinea pigs, and those experiencing weight loss, anorexia, or hypothermia would have a poorer outcome when undergoing a cystotomy.

Methods

Study design and inclusion criteria

The medical record database of a single veterinary referral hospital was reviewed for client-owned guinea pigs undergoing cystotomy for urolithiasis between 2010 and 2023. Cases were included if they were guinea pigs and had undergone a cystotomy with or without any additional procedures performed. All guinea pigs had radiographs prior to surgery that diagnosed the urolithiasis.

Data collected for each case included signalment (age, sex, breed, and reproductive status), presenting clinical signs, and vital parameters, including body weight, rectal temperature, heart rate, respiratory rate, mucous membrane color, capillary refill time, body condition score, and pain score. Additional data collected included radiographic location of the stone (urinary bladder vs urethra), stone size, intra- and postoperative complications, survival data, urolith type, and urinary culture results when available. Survival was defined as being alive at discharge from the hospital, and follow-up time was calculated from the day of surgery to the last known point of contact with the animal. Nonsurvival was defined as death prior to discharge.

Patient outcome was classified as excellent when surgical management led to resolution of the presenting clinical signs. Outcome was classified as good if mild presenting clinical signs persisted or recurred after surgery. Outcome was classified as poor if the patient died prior to discharge. All intraoperative and postoperative complications were recorded, which included deviations from normal body temperature (above or below 37.2 to 39.5 °C), hyporexia or anorexia, decrease or change in fecal production and quality, incisional abscessation, development of a uroabdomen, and cardiopulmonary arrest.

Statistical analysis

The response variable was time to death (survival time). The analysis was time-to-event (or survival) analysis with patients censored if time to death was not known (lost to follow-up). There were 18 factors that were tested for any association with survival time. These factors included age, sex, reproductive status, presence of hematuria, discomfort while urinating, hyporexia, owner-perceived weight loss, urinary obstruction, body weight, rectal temperature, heart rate, respiratory rate, mucous membrane color, body condition score, pain score, radiographic location of the stone, size of the stone, and urinary culture results. Initially, univariate tests (Kaplan-Meier or Cox regression for binary or continuous/ordinal data, respectively) were performed. Factors with univariate $P < .30$ were entered into a multivariate Cox proportional hazard model. Multicollinearity was assessed by means of variance inflation factor (VIF), with VIF < 2.5 considered acceptable. The proportional hazards assumption was assessed by means of plots of the scaled Schoenfield residuals versus time. The linearity assumption was assessed by means of the null Martingale residuals versus X. Factors were deleted from the model according to highest P value and were retained if $P < .05$. All previous unused or deleted factors were then added to the final model, noting P value and VIF; none were retained. $P < .05$ was considered significant. P values and risk ratios with 95% confidence limits were reported. All calculations were by means of NCSS 2023 statistical software (NCSS LLC).

Results

Patient demographics

A total of 25 guinea pigs were identified through the medical record search and fulfilled the inclusion parameters. Of the 25 guinea pigs identified, 6 (24%) were female (5 sexually intact and 1 neutered) and 19 (76%) were male (18 sexually intact and 1 neutered). The median age at presentation was 3 years (range, 1 to 6 years), and median weight was 1.02 kg (range, 0.76 to 1.28 kg). Median rectal temperature on admission was 39.72 °C (range, 35.56 to 40.0 °C). Median pain score was 3 (range, 1 to 4). Pain was

subjectively scored on a 6-point ordinal scale of 0 to 5, with 0 being no pain or disability and 5 being worst scenario of pain and body rigidity.[10] Physical examination parameters on presentation are summarized in **Table 1**.

Table 1—Physical examination parameters (median, range, and *P* value associated with survival) on presentation from 25 guinea pigs undergoing cystotomy.

	Median	Range	*P* value
Age (y)	3	1–6	.82
Body weight (kg)	1.02	0.76–1.28	.61
Rectal temperature (°C)	38.4	35.6–39.7	.56
Heart rate (beats/min)	260	28–230	.34
Respiratory rate (breaths/min)	65	28–230	.34
Body condition score*	5	3–7	.31
Pain score**	3	1–4	.89

*Out of 9. **Out of 5.

Presenting clinical signs

Owners' primary concerns upon presentation included hematuria (65% [16 of 25]), discomfort while urinating or defecating (75% [19 of 25]), hyporexia (48% [12 of 25]), and owner-perceived weight loss (20% [5 of 25]). A summary of presenting clinical signs is in **Table 2**.

Table 2—Presenting clinical signs from 25 guinea pigs undergoing cystotomy, percentage affected, and *P* values associated with survival.

	Present	Absent	Percentage affected	*P* value
Hematuria	16	9	64	.77
Discomfort	19	6	76	.025
Hyporexia	12	13	48	.15
Weight loss	5	20	20	.58
Urinary obstruction	7	18	28	.24

Seven guinea pigs (28%) were obstructed upon presentation. Of the presenting complaints, discomfort was the only clinical sign that was significantly associated with survival (*P* = .025). If the patient presented with signs of discomfort, the risk of dying prior to discharge was a sixth of the risk of dying if a patient presented without signs of discomfort (risk ratio = 0.177; 95% confidence limit = 0.039 to 0.802). Urinary obstruction was not associated with survival (*P* = .24).

Diagnosis and treatment

Uroliths were confirmed on radiographs in all 25 cases. A summary of stone size and location can be found in **Table 3**. Uroliths were most commonly found within the bladder (18 of 25 [72%]), while the remaining 9 patients (36%) had urethral stones with or without a bladder stone present. For patients with a stone within the urethra, the probability of death prior to discharge was 6 times that of patients with a stone within the bladder (*P* = .010 with risk ratio of 5.966). A urinalysis was performed in 4 out of 25 cases. All 4 samples were cloudy amber to brown in color, and all contained a large amount of protein and blood. The first sample had a pH greater than 9, marked rods, and calcium carbonate crystals. This was the only sample containing evidence of bacteria. The second sample had a pH of 8 with trace ketones and calcium carbonate crystals. The third sample had a pH of 8 and calcium dihydrate crystals. The fourth sample had a pH of 8 with calcium carbonate crystals.

Table 3—Radiographic location, stone size, and *P* value associated with survival in 25 guinea pigs undergoing cystotomy.

	Number	Percentage	*P* value
Radiographic location			.02 (urethra)
Bladder	16	64	
Urethra	9	36	
Stone size			.78
< 5 mm	5	20	
5–10 mm	13	52	
> 10 mm	2	8	

The majority of uroliths measured radiographically were 5 to 10 mm in size (13 of 20; 65%), while 5 (25%) guinea pigs had smaller uroliths measuring < 5 mm, and 2 (10%) had larger uroliths > 10 mm. Ultrasound examination of the urinary tract was performed in 3 cases. Ultrasound confirmed a urethrolith that was seen on radiographs in 1 case, found a left-sided ureterolith in addition to 2 cystoliths in the second case, and confirmed a cystolith at the trigone of the bladder also seen on radiographs in the third case. Only 4 of 25 (16%) guinea pigs had a urine culture performed, with results for 3 showing no growth and 1 with positive growth for *Actinomyces* spp.

Surgical removal of the cystoliths was offered to the owners in all cases. For premedication, all patients but 1 received midazolam (0.5 to 1.5 mg/kg) as well as a combination of buprenorphine (0.02 to 0.05 mg/kg), alfaxalone (0.5 to 2.5 mg/kg), and/or hydromorphone (0.3 to 0.4 mg/kg). Two patients received ketamine (1 to 2 mg/kg) and 1 patient received butorphanol (0.4 mg/kg) as part of their premedication protocols. Anesthesia was induced and maintained with either isoflurane or sevoflurane via mask. Patients were given glycopyrolate (0.01 to 0.02 mg/kg) for intraoperative hypotension in 4 cases. After surgery, if the patient had normal kidney values and was normotensive during surgery, they received either meloxicam (1 mg/kg, SC) or carprofen (2.2 mg/kg, SC). Eleven patients received metoclopramide (0.5 mg/kg, SC) upon recovery.

In all cases, a cystotomy was performed in the ventral body of the urinary bladder. All intraluminal uroliths were removed. A red rubber catheter was passed retrograde in all cases to flush out any urethroliths or uroliths. The urinary bladder was then closed and leak tested. The bladder was closed with 4-0 polydioxanone in a simple interrupted pattern in 11 cases, 3-0 polydioxanone in a simple interrupted pattern in 2 cases, 4-0 poliglecaparone in a simple interrupted pattern in 1 case, and 5-0 polydioxanone in a simple continuous pattern in 1 case. In the remaining 10 cases, the suture type or pattern was not known. Postoperative radiography was used in all cases to confirm that all stones were successfully removed. Radiographs for 3 guinea pigs showed the presence of a remaining stone postoperatively. Two patients went back to surgery to have the additional stone removed. Both patients survived to discharge.

The third patient was euthanized on the table due to inability to dislodge a urethral stone.

Preoperative analgesia consisted of multimodal analgesic plan (combination of opioids and NSAIDs). Postoperative analgesia consisted of opioids and NSAIDs. One patient was placed on a fentanyl continuous-rate infusion postoperatively at 3 µg/kg/h; 2 patients received tramadol, PO, every 12 hours (dose range, 8.6 to 9.7 mg/kg); and the remaining 22 patients received buprenorphine, IV or IM, every 8 hours (dose range, 0.05 mg/kg). Six patients received meloxicam 1 mg/kg, PO, once daily throughout their hospital stay. Four patients were discharged with gabapentin to be given once daily PO (dose range, 9.4 to 13.3 mg/kg). Twenty-one guinea pigs received a course of antibiotics that typically consisted of enrofloxacin (17 of 25 guinea pigs) at 5 to 10 mg/kg, PO, every 12 hours, although 5 cases received trimethoprim-sulfa at 27 to 32 mg/kg, PO, every 12 hours; 2 received metronidazole at 20 mg/kg, PO, every 12 hours; and 1 received azithromycin at 27 mg/kg, PO, once daily. Fifteen guinea pigs also received metoclopramide (0.5 mg/kg, SC or PO, q 8 to 12 h) to promote continued gastrointestinal (GI) motility. Intraoperative complications were recorded in 6 of 25 patients (24%), including prolonged hypotension (mean blood pressure < 60 to 70 mm Hg; 1 of 25 patients [4%]), hypothermia (body temperature < 37 °C; 3 of 25 patients [12%]), bradycardia (< 160 beats/min; 2 of 25 patients [8%]), inability to dislodge a urethrolith (1 of 25 patients [4%]), and the presence of a rent in a seminal vesicle (1 of 25 patients [4%]). One patient was euthanized intraoperatively due to the inability to dislodge the urethral stone. The other 24 patients survived surgery. Overall, 60% of guinea pigs (15 of 25 guinea pigs) survived to hospital discharge, and 40% (10 of 25 guinea pigs) were considered nonsurvivors. Of the 10 patients that did not survive to discharge, 1 was euthanized intraoperatively due to inability to dislodge a urethral stone, and 2 were euthanized 3 to 4 days after surgery due to a dull mentation and failure to improve clinically. Five guinea pigs arrested within 24 hours postoperatively. One of these patients arrested after a prolonged seizure. The other 4 respiratory arrested after becoming progressively dull and hypothermic following surgery. Two additional guinea pigs arrested 2 to 3 days postoperatively while still in the hospital. Both guinea pigs became progressively dull prior to respiratory arrest. The median duration of time in the hospital for patients successfully discharged was 4 days (range, 3 to 5 days).

Short-term complications (those that were noted in the hospital) were recorded in 19 of 25 patients (76%) postoperatively. These complications included hyper- or hypothermia (5 of 25 [20%]), hyporexia (5 of 25 [20%]), lethargy or dull mentation (4 of 25 [16%]), decreased fecal production (3 of 25 [12%]), diarrhea (2 of 25 [8%]), seizures (1 of 25 [4%]), remaining stones (1 of 25 [4%]), uroabdomen formation (2 of 25 [8%]), and cardiopulmonary arrest (6 of 26 [24%]). The patient that developed the uroabdomen was the only one that required a second surgical procedure. None of the patients that experienced cardiopulmonary arrest were able to be successfully resuscitated. In those that did not survive to discharge, the mean survival time was 1.2 days (range, 0 to 4 days; median, 0.4 days). In survivors, the median follow-up time was 71 days (range, 1 to 488 days; median, 21 days). Three patients died within a month of discharge. One patient died during an orthopedic procedure unrelated to the cystotomy. The other 2 patients died 21 and 30 days postoperatively; their causes of death were unknown.

Discussion

This study is the first to document risk factors, complications, and outcomes of a cohort of guinea pigs undergoing cystotomy for urolithiasis. In the study population, cystotomies were associated with an intraoperative complication rate of 24% and a short-term complication rate of 76%. Cystotomies were associated with a mortality rate of 40% prior to discharge and 52% within the first month postoperatively. We rejected our hypothesis that older patients, male guinea pigs, and those experiencing weight loss, anorexia, or hypothermia would have a poorer outcome when undergoing a cystotomy.

Abnormal urination is a common presenting complaint for guinea pigs presenting to the veterinary hospital, accounting for about 11% of clinical issues in this species.[5] These abnormalities include, but are not limited to, hematuria, stranguria, pollakiuria, or polyuria.[2–5,7] Several disease processes (eg, renal or uterine disease, urolithiasis, cystitis, or neoplasia) can cause these clinical signs.[3] In addition, 2 patients within this study presented with nonurinary signs alone, including hyporexia and owner-perceived weight loss. It is important not to exclude a urinary tract pathology in any guinea pig patient presenting with nonspecific clinical signs.[2] A thorough workup is needed to differentiate between these different pathologies and may consist of complete bloodwork, a urinalysis, and imaging (radiography vs ultrasonography).[6] Urolithiasis makes up about 43% of all guinea pig cases presenting for urinary disease.[2]

Historically, middle-aged to older guinea pigs are more commonly affected by urolithiasis, which remained consistent in our study.[2] The median age here was 3.2 years, with the average life span of a guinea pig reported to be 4 to 6 years.[11] There have been inconsistent data in the literature as to which sex is more predisposed to developing uroliths, though in our study boars outnumber sows, with 19 of 25 cases being male.[2] While stone composition is not always known, recent literature has shown that a majority of guinea pig uroliths have been identified as calcium carbonate.[1] The pathogenesis is not fully understood, but several factors have been implicated, including diets high in dark leafy greens or alfalfa hay, genetics, cystitis or nephritis, inappropriate husbandry, overconditioning, renal disease, dehydration, and urine retention.[5] Given the typical calcium carbonate composition of stones in guinea pigs, urolithiasis is usually detectable on radiographs. Other imaging modalities are typically not needed, as radiographs are often sufficient to determine the location of the stones.[2–5] However, with other stone types, abdominal ultrasound may be useful.[5] In our study, only stones from 2 patients were submitted for analysis. One stone was calcium carbonate and monohydrate, and the other was calcium phosphorous apatite. However, all stones were radiopaque on radiographs. In the 3 cases in which the patients received

an ultrasound, the ultrasonographic findings did not change the recommended treatment.

While urolithiasis can be a life-threatening condition depending on the size and location of the stone, findings of the present study showed that cystotomies may carry a high mortality rate. Any ventral abdominal surgery in guinea pigs should be performed with caution due to the high risk of postoperative complications, most notably postsurgical ileus.[12] Postoperative ileus typically lasts 3 to 4 days following surgery. The most common manifestations of ileus within the guinea pig population include pain, bloating, abdominal distension, nausea, vomiting, and decreased gut sounds. The mechanism of postoperative ileum is multifactorial but has been shown to be significantly associated with inflammation.[13] Guinea pigs tend to have a more exaggerated inflammatory response associated with handling of their GI tract in relation to other small animal species.[7] The surgeons within this study's institution attempt to avoid handling the GI tract when performing cystotomies. Even when the most delicate soft tissue–handling skills are used, patients will experience acute-onset inflammation within the muscular layer of the intestinal wall. Greater inflammatory responses lead to increased duration and severity of GI dysmotility.[13] It has not been documented how anesthetic agents affect postoperative GI ileus in guinea pigs. Ileus postoperatively may necessitate the use of promotility agents in the hospital and after discharge.[13] Other common complications following abdominal surgery include adhesions and peritonitis.[12,11,14] Adhesions can be minimized via delicate tissue handling and the use of the least reactive suture material possible.[11] The risk of peritonitis can be reduced by maintaining strict sterility and lavaging the abdomen thoroughly prior to closure.[11]

Guinea pigs tend to be more sensitive to pain and GI manipulation when compared to other rodents, so ventral abdominal surgery is generally avoided whenever possible.[14] Because of the complications associated with manipulation of the GI tract, many clinicians prefer a flank approach, when possible, for procedures such as ovariectomies where the target organs may be accessed without GI tract handling.[7,14] A recent study even investigated a laparoscopic technique for ovariectomy and showed that it can be a feasible alternative to open ovariectomy as an elective surgical technique.[14] Minimally invasive techniques for cystotomies may improve overall outcome by reducing the complications associated with handling the GI tract such as ileus, adhesions, and peritonitis. Transurethral cystoscopy has been investigated as an alternative method for cystolith and urethrolith retrieval.[6] This technique has been used in female guinea pigs whose urethral diameter is larger than that of male guinea pigs. Even so, it has been reported that this technique is only feasible for stones with diameters < 5 to 6 mm.[6] This is a significant limitation for male guinea pigs or female guinea pigs with larger stones. In our study, a majority of stones were 5 to 10 mm.

There is currently a paucity of literature documenting mortality and prognosis associated with ventral abdominal procedures in general for guinea pigs. It is unclear here why guinea pigs tend to have a poor outcome associated with cystotomies, particularly because a caudal abdominal approach avoids significant manipulation of the GI tract. However, it has been found that medical management of urolithiasis is frequently not successful in guinea pigs, leading clinicians to recommend surgical intervention.[2] It may be of benefit to consider alternative retrieval or removal methods such as cystoscopy or lithotripsy, if feasible, to reduce the risk of morbidity or mortality to the patient given the findings of this study. Further studies are needed to investigate the feasibility and outcome of these procedures in guinea pig patients.

Age did not affect outcome in this study. This is in contrast to the Edell et al[2] study, where increased age was statistically significant, with a 21.2% greater chance of death if over > 4.1 years old. It is possible that statistical significance was not found in the study reported here because the study population was overall younger, with a median age of 3 instead of 4 and a range of 1 to 6 rather than 0.33 to 8.83 years. Additionally, we found that sex did not affect outcome, unlike in the Edell et al[2] study. Peng et al[15] showed that 5 of the 6 guinea pigs diagnosed with urolithiasis on necropsy were female. However, due to anatomical differences between male and female guinea pigs, including urethral length and diameter, many of the female guinea pigs in the Edell et al study were treated nonsurgically with manual removal or voiding of the uroliths.[2,4] This conferred a better prognosis for female patients. However, in the current study, all guinea pigs were treated surgically, making anatomical differences less of an influencing factor on outcome.

In our study, in contrast to Edell et al,[2] the presence of anorexia and weight loss did not affect outcome. Surgical intervention via a cystotomy provides immediate resolution to the presence of cystoliths and urethroliths. Medical management with fluids and pain control on the other hand may prolong clinical signs associated with urolithiasis.[7] This may cause exacerbation of the anorexia and weight loss, conferring a poorer outcome in these patients. In addition, the presence of hypothermia on presentation also did not affect outcome. This is likely because in our study population, the median rectal temperature at presentation was 38.4 °C, with only 1 patient presenting with hypothermia at 35.6 °C. Because of this, no statistical significance could be found associated with rectal temperature.

In our study, owner-perceived discomfort had a statistically significant effect on outcome. Signs of discomfort while urinating, such as teeth grinding, a hunched posture, and vocalizing, are likely more apparent to owners than more subtle signs like hyporexia or weight loss. This may decrease the time to presentation and time to treatment. However, the time from onset of clinical signs to presentation was not recorded in this study, so this postulation cannot be confirmed. The risk ratio for hyporexia was 3.0, meaning that if the patient presented with hyporexia, they were seemingly 3 times as likely to die prior to discharge. However, this was not statistically significant (*P* value = .069). Further studies with a greater number of cases are needed. In addition, the presence of a urethral stone had a statistically significant effect on outcome. We suspect this is likely because patients with urinary obstructions are sicker overall

patients with biochemical and electrolyte derangements that make it more difficult for them to recover from surgery and anesthesia.[2–5,7] Bloodwork was not performed in most patients within this study, so potential biochemical and electrolyte changes cannot be confirmed.

Given the suggested guarded outcome associated with cystotomies, it is crucial as a clinician to recommend husbandry changes for any patient presenting with urolithiasis since the risk of recurrence is high.[2] Reducing the consumption of high-calcium diets such as those consisting mostly of alfalfa hay or pellets can potentially reduce the risk of calcium carbonate stone formation. In addition, increasing a guinea pig's water consumption can preserve diuresis to reduce calcium salt deposition within the urinary tract. Having a variety of water sources such as water bottles and water bowls may encourage increased water consumption.[1–5,7,8]

This study has several limitations. The first limitation is the retrospective nature of this study, leading to gaps in some of the data as well as limited follow-up. Another limitation is the small number of cases. Future studies with a larger number of patients at multiple institutions are needed. In addition, there was no standardization regarding which diagnostics were performed preoperatively or postoperatively for the patients included in this study. More information may be obtained if a larger number of patients had ultrasounds, bloodwork, urinary cultures, or stone analyses performed. More information could also be obtained regarding the postoperative survival rate for other abdominal surgeries in guinea pigs at this institution, as this data has not been analyzed. Finally, the cause of death is not known for most of the patients, as owners did not elect to perform necropsies. This makes it difficult to gain any information as to why the mortality rate for this particular surgery is so high.

In conclusion, 60% of guinea pigs survived to hospital discharge. Discomfort was the only clinical sign that was significantly associated with survival. In addition, for patients with a stone within the urethra, the probability of death prior to discharge was 6 times that of patients with a stone within the bladder. In general, medical management is often unsuccessful for the treatment of urolithiasis, so surgical intervention is often warranted, despite the high mortality rate. If proceeding with a cystotomy procedure, owners should be warned about the risks and complications associated with surgery and the possibility of intraoperative and postoperative death. Further studies are needed to determine whether other factors carry a statistical significance associated with survival and what specifically may lead to the increased mortality in guinea pigs undergoing cystotomies as well as whether alternative minimally invasive procedures may be helpful in improving guinea pig outcomes with urolithiasis.

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