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Effect of patient positioning on retrieval of cystoliths by percutaneous cystolithotomy in dogs

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ABSTRACT

Percutaneous cystolithotomy (PCCL) is a minimally-invasive technique for removal of cystoliths. There is currently no information regarding optimum patient positioning during PCCL. The objective of this study was to assess whether patient positioning affected ease of cystolith retrieval via PCCL. PCCL was performed to retrieve artificial "cystoliths" in three canine cadavers weighing between 15 and 35 kg, using a threaded cannula and a rigid 30° 2.7 mm cystoscope. "Cystolith" retrieval was performed by retrograde flushing and use of a flexible stone basket, with the dog in 10° Trendelenburg, 10° reverse Trendelenburg, or neutral position. The location of the "cystoliths", number retrieved during flushing, and total time for retrieval were recorded and compared between different positions. The mean total time for "cystolith" retrieval was 392 ± 131 s, with 162 ± 20 s for flushing and 221 ± 123 s for basket-retrieval. The mean number of "cystoliths" retrieved during flushing was 3 ± 2. No significant differences were detected when comparing retrieval times between different positions. The predominant location of the "cystoliths" within the bladder varied depending on the position of the dog. In neutral, 93 % were located adjacent to the ureteric openings, whereas in 10° reverse Trendelenburg, 100 % were located by the urethral orifice. In 10° Trendelenburg, 60 % "cystoliths" were located at the tip of the cannula. Cystolith retrieval during PCCL can be performed in either neutral, Trendelenburg or reverse Trendelenburg position. Changing the dog's position may be useful in cases where cystolith retrieval is challenging, to move the cystoliths and enable different techniques to be employed using the stone basket.

Introduction

Urolithiasis is a common cause of lower urinary tract signs including hematuria, stranguria, dysuria and urethral obstruction in dogs (Bartges and Callens, 2015). The current recommendation for urolith management is removal of cystoliths only if they are associated with clinical signs or if they are of a size that could cause urethral obstruction (Lulich et al., 2016; Cléroux, 2018). Minimally invasive endoscopic retrieval techniques are recommended as they are associated with shorter hospitalization times, lower complication rates and decreased risk of incomplete calculi removal due to improved visualization (Arulpragasam et al., 2013; Lulich et al., 2016; Singh et al., 2016; Cléroux, 2018).

Percutaneous cystolithotomy (PCCL) is a minimally invasive technique that provides a magnified view, with illumination and improved visualization of the entire bladder, and can also be used to inspect the urethra for any remaining urinary calculi. The PCCL technique is not limited by urethral and calculus size as with transurethral cystoscopic-guided basket retrieval, and does not require multiple incisions or creation of pneumoperitoneum as with laparoscopic-assisted cystotomy (Rawlings et al., 2003; Runge et al., 2011; Cléroux, 2018; Cruciani et al., 2020).

There is currently no information in the human or veterinary literature regarding the effect of patient positioning when performing PCCL. It is routinely performed with the patient in dorsal recumbency with the table horizontal. The objective of this cadaveric study was therefore to assess whether the use of Trendelenburg or reverse Trendelenburg positions affects the ease of cystolith retrieval during PCCL by altering the relative position of the cystoliths to the cannula tip and stone basket within the bladder. The null hypothesis was that the time taken for cystolith retrieval by PCCL would not change depending on the position of the dog.

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Materials and methods

Procedure

Ethical approval was granted by the University of Cambridge Department of Veterinary Medicine Ethics and Welfare Committee (CR450, 2 October 2020). Ten artificial "cystoliths" measuring 2–9 mm in diameter were made from air-dried clay, aiming to recreate the shape, size and weight of normal cystoliths as closely as possible. A colored waterproof lacquer was applied to prevent disintegration of the clay when submerged over time, with the coloring used to help distinguish between the different size categories of the "cystoliths".

Three canine cadavers (15–35 kg) with no reported history or clinical signs of lower urinary tract disease that had been euthanized for reasons unrelated to the study, were positioned in dorsal recumbency with the operating table initially in a neutral position. At the time of euthanasia, the owners of these dogs had given written consent for them to be used for teaching or research purposes. "Cystolith" retrieval was repeated five times in each position for each dog. The order of use of the cadavers and the order of the positions used for the PCCL procedure was randomized using a random number generator.

The ventral abdomen and prepuce or vulva were clipped. An eight French Foley urinary catheter was placed into the urethra and 1 ml/kg of water was instilled into the bladder to distend it and allow palpation of the position of the bladder apex. PCCL was performed as previously described (Runge et al., 2011; Cruciani et al., 2020); a 2 cm ventral midline mini-laparotomy was performed at the position of the bladder apex. The bladder was identified, and three stay sutures (3–0 polypropylene) were placed ventrally at the apex in a triangular pattern. The bladder was elevated to the laparotomy and a stab incision was made between the stay sutures. The "cystoliths" were placed in the bladder via the stab incision. The angle of the operating table was adjusted to either ten degrees Trendelenburg, ten degrees reverse Trendelenburg, or neutral position. A 6 mm endoscopic threaded cannula with a silicone leaflet valve (Ternamian EndoTip cannula, Karl Storz Endoscopy Ltd) was inserted (Fig. 1) and a rigid 30° 2.7 mm cystoscope (Hopkins II Forward-Oblique Telescope 30°, Karl Storz Endoscopy Ltd) with an operating sheath (Sheath, Karl Storz Endoscopy Ltd) was used to inspect the bladder. The position of the "cystoliths" within the bladder was recorded.

The valve was removed from the cannula and 1 ml/kg of water was rapidly instilled via the urinary catheter with additional manual pressure applied to the abdomen over the bladder to attempt to flush out the smaller "cystoliths". This was repeated five times using the same volume of water, with the cannula maintained in the same position throughout. The number of "cystoliths" retrieved and the time taken for flushing were recorded.

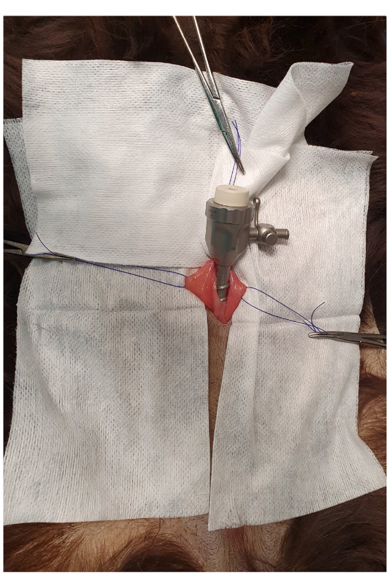

Fig. 1. Operative setup for percutaneous cystolithotomy, with threaded cannula in place.

The valve was replaced on the cannula and the cystoscope re-inserted. A 2.4 French flexible stone basket (NCompass Nitinol Stone Extractor, Cook UK Ltd) with a 1.5 cm basket diameter was used to retrieve the remaining "cystoliths", which were either withdrawn through the cannula, or with the cannula through the cystotomy incision for those larger than 6 mm. The time taken for basket-retrieval of the remaining "cystoliths", time per "cystolith", and the total time for retrieval of all "cystoliths" were recorded. One author (RK) manipulated the cystoscope and stone basket position, and the other author (LO) operated the stone basket opening and closing mechanism for all procedures.

Statistical methods

Statistical analysis was performed using standard computer statistics software (IBM SPSS Statistics 27, IBM). Normality of continuous data was assessed using histograms and Shapiro-Wilk tests. All continuous data groups had a lognormal distribution, so were described by the geometric mean ± standard deviation. Categorical data was expressed as percentages. "Cystolith" retrieval times were compared between different positions using one-way analysis of covariance (ANCOVA) with post-hoc Bonferroni paired comparisons. Procedure order and the dog used were included as co-variates to control for improvements in time with experience. "Cystolith" location was compared between different positions with a Chi-squared test. Statistical significance was set at $P \leq 0.05$.

Results

Forty-five "cystolith" retrieval procedures were performed. The mean total time for "cystolith" retrieval was 392 ± 131 s, with 162 ± 20 s for flushing and 221 ± 123 s for basket-retrieval (31 ± 22 s per "cystolith"). The mean number of "cystoliths" retrieved during flushing alone was 3 ± 2. Total time for retrieval and time for basket-retrieval decreased significantly as experience with the procedure increased during the first 25 procedures ($P < 0.01$), after which there was a plateau for both parameters.

The mean total times for "cystolith" retrieval in each of the different positions were within one minute of each other. No statistically significant differences were detected for "cystolith" retrieval time or the number of "cystoliths" retrieved during flushing in different positions (Table 1).

The location of the "cystoliths" within the bladder varied between different positions ($P < 0.01$) (Fig. 2). In neutral, 93 % were located adjacent or cranial to the ureteric openings (Fig. 3), whereas in ten degrees reverse Trendelenburg, 100 % were located by the urethral

Table 1
"Cystolith" retrieval data for different positions.

	10° Trendelenburg	Neutral	10° Reverse Trendelenburg
"Cystoliths" retrieved by flushing	2 ± 2	3 ± 2	3 ± 2
Time for flushing (s)	156 ± 20	167 ± 17	164 ± 21
Time for basket-retrieval (s)	220 ± 112	242 ± 157	203 ± 78
Time for basket-retrieval per "cystolith" (s)	29 ± 12	35 ± 33	29 ± 14
Total time for "cystolith" retrieval (s)	384 ± 121	421 ± 165	372 ± 85

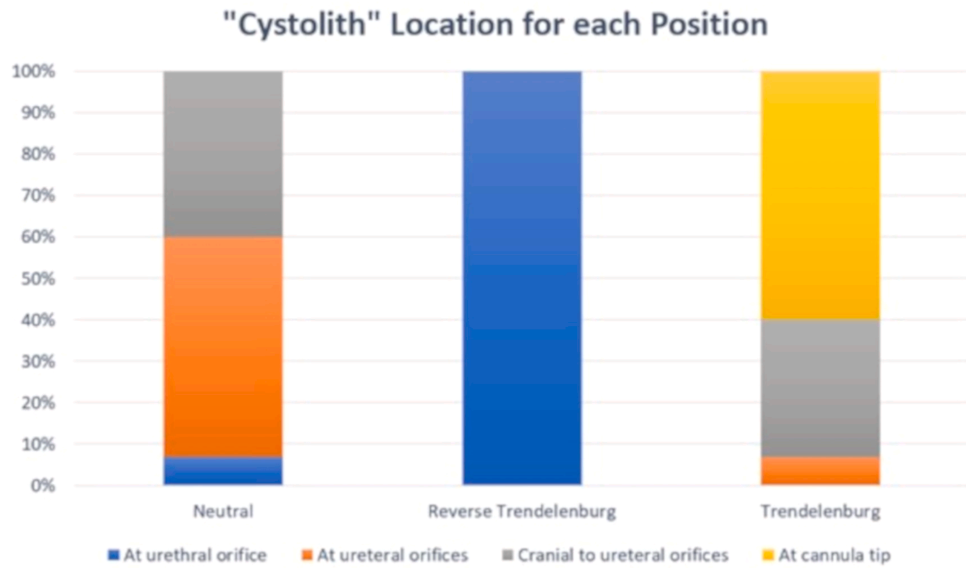

Fig. 2. Stacked bar chart demonstrating "cystolith" location for each position.

Fig. 3. "Cystoliths" located adjacent to the ureteric openings (circled) with the dog in a neutral position.

orifice, resting against the balloon of the Foley catheter (Fig. 4). In ten degrees Trendelenburg, 60 % "cystoliths" were located around the tip of the cannula (Fig. 5).

Discussion

This study demonstrated that cystolith retrieval during PCCL can be performed in either neutral, Trendelenburg or reverse Trendelenburg position in dogs. Based on these results, it was not possible to reject the null hypothesis that the time taken for cystolith retrieval by PCCL would be the same independent of the position of the dog.

Previous studies reporting the PCCL technique have not described the optimum positioning for performing this procedure (Runge et al., 2011; Cruciani et al., 2020). In the description of laparoscopic-assisted cystoscopy by Rawlings et al., dogs were placed in Trendelenburg position, to encourage cranial movement of the bladder within the abdomen so it could be more easily manipulated to the port site, although no comparison was made with other positions (Rawlings et al., 2003). This study showed that it was feasible to perform PCCL in neutral, Trendelenburg and reverse Trendelenburg positions and that there was no significant difference in the time taken for "cystolith"

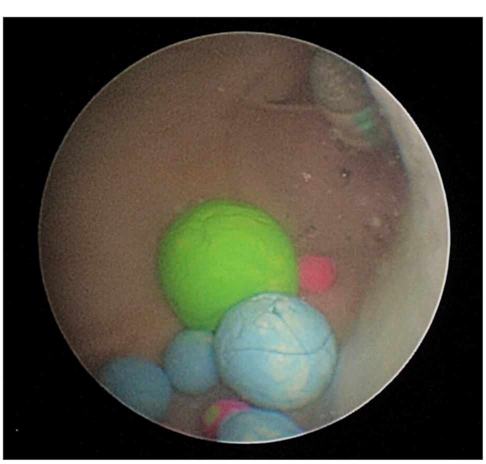

Fig. 4. "Cystoliths" located by the urethral orifice, resting against the balloon of the Foley catheter, with the dog in ten degrees reverse Trendelenburg position.

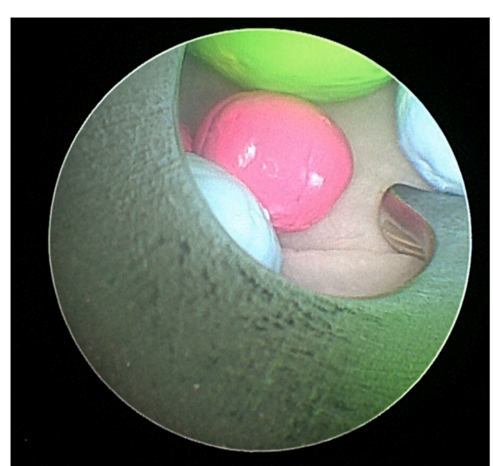

Fig. 5. "Cystoliths" located around the tip of the cannula with the dog in ten degrees Trendelenburg position.

retrieval or the number of “cystoliths” retrieved by flushing in the different positions. The original hypothesis was based on the idea that the “cystoliths” would move with gravity relative to the tip of the cannula, and that this would affect the ease of retrieval with flushing or the stone basket. The “cystoliths” did move within the bladder with different positioning, but this did not make it more difficult overall to retrieve them successfully via either method.

Although not a quantifiable variable, different methods for basket-retrieval were more effective in the various “cystolith” locations within the bladder and in different positions. In the reverse Trendelenburg position, opening the stone basket at the urethral orifice and moving cranially allowed “cystoliths” to roll caudally into the basket with gravity. In Trendelenburg position, the “cystoliths” moved cranially, resting against a “step” created where the bladder exited the laparotomy incision, which could be used to stabilize the “cystoliths” when manipulating the basket around them. Altering the dog’s position may be useful in cases where cystolith retrieval is more challenging, to move the cystoliths within the bladder and enable different techniques using the stone basket.

The decreased retrieval time for “cystoliths” observed as experience was gained is to be expected due to the learning curve associated with all surgical and laparoscopic procedures. The learning curve associated with laparoscopic procedures has been reported in both human and veterinary literature (Ghomi et al., 2007; Runge et al., 2014; Grivas et al., 2021). When evaluating the learning curve for laparoscopic single-site ovariectomy in dogs, Runge et al. reported a 27 % decrease in surgical time with each procedure, with 90 % of optimal performance reached after approximately eight procedures (Runge et al., 2014). In this study, the total time for retrieval and the time for basket-retrieval of “cystoliths” decreased during the first 25 procedures, after which a plateau was observed. This suggests that the learning curve for a surgeon with a similar level of previous experience of performing PCCL could be expected to be approximately 25 cases. Further research with a skill acquisition model would be required to investigate this more definitively, as this study was not specifically designed to assess the learning curve for this procedure.

There are some important limitations to this study. A sample size calculation could not be performed due to a lack of previous data on which to base assumptions, and the logistical considerations with sourcing large numbers of cadavers limited the sample size, so a type two statistical error is possible. However, the difference in timings between positions were less than one minute, which is unlikely to be clinically relevant for the overall procedure time, even if it were statistically significant. The artificial “cystoliths” were created to mimic real cystoliths as closely as possible in shape, size, and mass, but more irregular, jackstone-shaped cystoliths may behave differently. None of the dogs in this study had lower urinary tract signs reported prior to euthanasia or gross abnormalities on cystoscopic examination. Visualization and retrieval of “cystoliths” during PCCL in live bladders may be affected by hemorrhage and inflammation, which is not present in cadaveric bladders, but “cystolith” retrieval should not otherwise be particularly different in cadavers as it does not rely on healing or other cellular responses. This study also did not assess the effect of positioning on the ease of cystolith retrieval if they move into the urethra during the procedure, so this aspect could be investigated in future studies.

Conclusions

Cystolith retrieval during PCCL can be performed in either neutral, Trendelenburg, or reverse Trendelenburg position in dogs, and this study describes alternative strategies which may be useful during challenging PCCL cases. These results also indicate that performing PCCL should not be affected if the dog’s position needed to be altered for other reasons, such as positioning in reverse Trendelenburg to relieve pressure on the diaphragm to achieve adequate ventilation.

Conflict of Interest

None of the authors has any financial or personal relationships that could inappropriately influence or bias the content of the paper.

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