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Feasibility of cannula-free single-port percutaneous cystolithotomy using a 5-mm operative hysteroscope in dogs with varying procedural constraints: a retrospective case series

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Abstract

Conventional percutaneous cystolithotomy (PCCL) in dogs typically relies on a transvesical access cannula as the working channel for stone retrieval. This retrospective case series

evaluated the feasibility and clinical outcomes of a novel cannula-free single-port PCCL technique in dogs with varying procedural constraints. Procedural constraints were retrospectively characterized using an exploratory composite framework incorporating body-related and disease/anatomy-related factors. The technique repurposes a 5-mm operative hysteroscope as a laparoscopic access device, enabling bladder visualization and traction through an initial single 5-mm access site before conversion to a cannula-free working window for stone retrieval. Ten dogs underwent the procedure, and procedural completion, stone removal, operative time, postoperative recovery, and perioperative clinical findings were evaluated. The intended procedure was completed in all 10 dogs, including three cases classified as high-constraint, with complete stone removal achieved in every case. Operative times and times to sternal recumbency and standing varied among dogs, while postoperative pain scores decreased from 6 to 24 h after surgery. These findings provide preliminary evidence supporting the clinical feasibility of cannula-free single-port PCCL in dogs presenting a range of procedural constraints, including cases with multiple concurrent constraints. Larger studies are needed to further characterize its clinical outcomes.

Keywords

Percutaneous cystolithotomy; Operative hysteroscope; Procedural complexity; Dogs

Introduction

Urinary bladder calculi are a common urologic disorder in dogs, and mechanical removal by surgical or minimally invasive techniques is often required when medical dissolution is unsuccessful or inappropriate [1-3]. Percutaneous cystolithotomy (PCCL) has been used as a minimally invasive alternative to conventional cystotomy because it allows effective stone

removal while reducing surgical trauma and facilitating postoperative recovery [3-6]. However, procedural complexity during PCCL may vary considerably among patients, particularly when anatomical or disease-related factors limit bladder access or restrict instrument maneuverability [2, 7].

Previous surgical intervention and chronic inflammatory changes may alter normal anatomy or restrict surgical access, potentially increasing procedural difficulty [8]. Patient size and body conformation may influence technical aspects of minimally invasive procedures [8-11]. Although these factors may present technical challenges, the feasibility of PCCL techniques in dogs presenting diverse body-related and disease/anatomy-related procedural constraints remains incompletely characterized.

With the aim of addressing technical limitations associated with restricted working space and instrument crowding, we developed a cannula-free single-port PCCL technique using a 5-mm operative hysteroscope. Unlike previously described PCCL techniques that primarily use a transvesical access cannula as the working channel during stone retrieval [4, 7, 9] , the present approach combined pneumoperitoneum-based laparoscopy, hysteroscope-assisted bladder elevation, and cannula-free transvesical instrumentation through a single 5-mm access site.

These modifications were intended to facilitate procedural access and instrument maneuverability under varying technical constraints. Therefore, this retrospective case series evaluated the technical feasibility and clinical outcomes of cannula-free single-port PCCL in dogs presenting a range of body-related and disease/anatomy-related procedural constraints.

Materials and Methods

Study design

Medical records of client-owned dogs that underwent cannula-free single-port PCCL using a 5-mm operative hysteroscope at a private veterinary hospital in the Republic of Korea between February, 2026 and June, 2026 were retrospectively reviewed. All consecutive cases treated with the described technique during the study period were included. A total of 10 dogs were identified and included in the study. Clinical information, including body weight, body condition score, previous surgical history, and relevant preoperative imaging findings, was retrieved from the medical records.

Characterization of procedural constraints

Procedural constraints were retrospectively characterized using a composite framework incorporating body-related and disease/anatomy-related factors considered relevant to operative workspace, bladder access, and instrument maneuverability during PCCL. Adequate working space is important for visualization and instrument manipulation during minimally invasive surgery, and relationships between body weight, body conformation, and intra-abdominal volume have been investigated in dogs [10, 11]. Body-related constraints were assigned a maximum score of 3, with one point each for body weight <3.5 kg, body condition score ≤3/9, and either a thoracic girth-to-body weight ratio <9 cm/kg or a body length-to-body weight ratio <12 cm/kg. The morphometric ratios were included based on clinical surgical experience suggesting that relatively smaller body dimensions in relation to body weight may be associated with restricted operative workspace and instrument maneuverability. Disease/anatomy-related constraints were also assigned a maximum score of 3, with one point

each for the presence of fibrosis or adhesion, previous surgery, and anatomical distortion. The body-related and disease/anatomy-related scores were summed to generate a composite constraint score ranging from 0 to 6.

Cases with composite scores of 0–2 were descriptively categorized as low-constraint, whereas those with scores ≥3 were categorized as high-constraint. The selection of variables, equal weighting of individual factors, and cutoff values were informed by clinical surgical experience and were not formally validated as measures of procedural difficulty. The framework was intended to characterize the heterogeneity of access-related technical constraints represented in this case series rather than to predict procedural outcomes or support inferential comparisons between constraint categories.

Preoperative management

All dogs had food and water withheld for 12 h and 6 h, respectively. Prophylactic trimethoprim–sulfamethoxazole (15 mg/kg, IV or SC) was administered. Anesthesia was induced with propofol and maintained with sevoflurane in oxygen. Intravenous fluids and monitoring were maintained throughout anesthesia.

Surgical procedure

The defining technical feature was the use of a 5-mm operative hysteroscope as a laparoscopic access device , providing both laparoscopic visualization and bladder traction through its integrated working channel. Following induction of general anesthesia, dogs were positioned in dorsal recumbency, and a 6–8 Fr urinary catheter was placed for bladder decompression and

saline distension. Pneumoperitoneum (8–10 mmHg) was established, and a 5-mm trocar was inserted through a ventral midline (female) or left paramedian (male) approach (Fig. 1A). A 5-mm operative hysteroscope was introduced, and the bladder apex was grasped with 3-mm laparoscopic micro-forceps passed through its working channel and elevated to the abdominal wall under laparoscopic visualization (Fig. 1B, F). The trocar was then removed while maintaining bladder apposition, creating a cannula-free single-port working window. The bladder apex was secured with a craniocaudal stay suture and bilateral mosquito forceps, followed by a 3–5 mm cystotomy (Fig. 1C). This orthogonal fixation maintained firm apposition of the bladder to the abdominal wall while keeping the cystotomy patent, thereby facilitating repeated instrument passage and controlled angulation of the cystoscope through the cannula-free access site. An 8/9.8-Fr pediatric operative cystoscope was inserted directly through the cystotomy without a cannula (Fig. 1D). The absence of a rigid cannula allowed scope angulation and gentle expansion of the compliant cystotomy margins during stone extraction without restricting retrieval to the internal diameter of a fixed cannula. Uroliths were removed using a nitinol basket or grasping forceps, and larger calculi were fragmented using a holmium:YAG laser when required. Residual urethral calculi were identified by intraoperative radiography and confirmed endoscopically. Detected calculi were flushed into the bladder or fragmented in situ. Complete stone clearance was confirmed by repeat cystoscopy and, when indicated, intraoperative radiography or ultrasonography. The bladder, abdominal wall and skin were closed routinely (Fig. 1E).

Postoperative management

Dogs were hospitalized for 3 days. Lactated Ringer's solution (5–10 mL/kg/h, IV), tramadol (2 mg/kg, IV), and trimethoprim–sulfamethoxazole (15 mg/kg, IV or SC) were administered postoperatively, with butorphanol (0.2 mg/kg, IV) used as rescue analgesia. Patients were

monitored for complications. Urinary catheters were removed after positive-contrast cystography confirmed bladder integrity without contrast leakage.

Outcome assessment

Procedural feasibility was primarily assessed by successful completion of the intended cannula-free single-port PCCL procedure and complete stone removal without conversion to an alternative surgical approach. Complete stone removal was confirmed by repeat cystoscopy and, when indicated, intraoperative imaging. Intraoperative and postoperative complications were recorded. Secondary clinical outcomes included operative time, time to sternal recumbency and standing, and postoperative pain assessed using the Colorado State University Canine Acute Pain Scale (CSU-CAP). Blood samples were collected preoperatively and 24 h postoperatively for measurement of CRP, cortisol, and glucose concentrations.

Statistical analysis

Given the retrospective case-series design and small sample size, data were analyzed descriptively. Continuous variables were summarized as median and interquartile range (IQR), and categorical variables as number and percentage. Procedural constraint categories were used solely to characterize the heterogeneity and range of technical challenges represented in the included cases and were not treated as comparison groups for hypothesis testing. Accordingly, no inferential statistical comparisons were performed between constraint categories. Statistical summaries were generated using R (R Foundation for Statistical Computing, Vienna, Austria).

Results

Case characteristics

A total of 10 dogs were included in the study. Based on the descriptive procedural constraint framework, seven cases were categorized as low-constraint and three as high-constraint. Composite constraint scores ranged from 1 to 5, with scores of 4, 4, and 5 in the three high-constraint cases. The cohort represented a range of body-related and disease/anatomy-related procedural constraints, including small body size, low body condition score, fibrosis/adhesion, previous surgery, and anatomical distortion (Table 1).

Urolith characteristics

Bladder calculi were present in all 10 dogs, and concurrent urethral calculi were identified in one dog (Table 2). The number of calculi varied widely among cases, with a median of 4 [IQR, 1.25–18.25] calculi overall. The median largest stone diameter was 8.7 mm [IQR, 7.25–11.75 mm].

Procedural feasibility and operative outcomes

The intended cannula-free single-port PCCL procedure was successfully completed in all 10 dogs without conversion to an alternative surgical approach, with complete stone removal achieved in every case. No intraoperative or postoperative complications were observed. Operative times for individual dogs are shown in Fig. 2. Postoperative recovery outcomes are shown in Fig. 3. Pain scores decreased from 6 to 24 h after surgery, while times to sternal recumbency and standing varied among individual dogs.

Physiologic responses

Perioperative inflammatory and stress-related biomarker responses are shown in Fig. 4. CRP concentrations increased from baseline to 24 h after surgery in all dogs. Changes in cortisol and glucose concentrations varied among individual dogs.

Hematologic and biochemical findings

Perioperative hematologic and biochemical findings for the overall cohort are summarized in Table 3. Median WBC count increased from 9.30 [IQR, 7.77–10.24] $\times 10^3/\mu L$ at baseline to 13.60 [IQR, 11.38–19.48] $\times 10^3/\mu L$ at 24 h after surgery. Median TP concentration decreased from 7.10 [IQR, 6.88–7.28] to 6.45 [IQR, 6.08–6.83] g/dL, and median ALB concentration decreased from 3.45 [IQR, 3.18–3.68] to 2.90 [IQR, 2.73–3.08] g/dL.

Discussion

The principal finding of this study was that the cannula-free single-port PCCL technique using a 5-mm operative hysteroscope was successfully completed in all 10 dogs, with complete stone removal achieved in every case. The included dogs represented a heterogeneous clinical population with varying body-related and disease/anatomy-related procedural constraints. These findings support the clinical feasibility of the technique across the range of procedural constraints represented in this case series.

Several factors may contribute to procedural complexity during PCCL. Previous surgical intervention and chronic inflammatory changes may alter normal anatomy or restrict surgical access [8], while body-related characteristics may influence operative workspace and instrument maneuverability [10, 11]. The constraint framework used in this study was intended

to characterize these access-related challenges rather than to compare clinical outcomes between constraint categories. Stone number and maximum stone diameter were evaluated separately because they may influence stone retrieval without necessarily reflecting the constraints associated with operative access or instrument maneuverability. Accordingly, the framework should be interpreted as a descriptive characterization of case heterogeneity rather than as a validated measure of procedural difficulty.

Direct intravesical visualization, together with laparoscopic visualization of the bladder exterior, may have facilitated instrument maneuverability within a restricted operative field. These features are particularly relevant to single-port surgery, in which reduced triangulation, instrument crowding, and confined operative spaces are recognized technical challenges [12-14].

A distinctive feature of the present technique was the use of a 5-mm operative hysteroscope as a laparoscopic access device. The hysteroscope was used for visualization and bladder traction before removal of the trocar to establish a cannula-free working window. This configuration allowed instrument angulation through the cannula-free working window without restriction by the fixed internal diameter of a transvesical cannula. The compliant cystotomy margins could also accommodate stone extraction without requiring retrieval through the lumen of a fixed cannula. These technical characteristics may have facilitated instrument manipulation and stone retrieval in dogs with differing anatomical and body-related constraints.

Postoperative recovery was characterized by a decrease in pain scores from 6 to 24 h after surgery, while times to sternal recumbency and standing varied among individual dogs. These findings provide descriptive information regarding short-term recovery following the procedure but do not establish differences or equivalence in recovery between constraint categories.

Perioperative inflammatory and stress-related biomarker responses varied among individual dogs. CRP concentrations increased from baseline to 24 h after surgery in all dogs, whereas changes in cortisol and glucose were more variable. Postoperative CRP concentrations commonly increase during the first 24 h after surgery in dogs [15].

CRP and cortisol are used as indicators of postoperative inflammation and physiological stress responses [16, 17] , and postoperative CRP responses have been associated with the extent of tissue injury [18, 19]. However, the present study was not designed to determine whether procedural constraint level was associated with the magnitude of these responses. Therefore, the observed changes should be interpreted as descriptive perioperative findings rather than evidence of differences between constraint categories.

Perioperative hematologic and biochemical findings provided additional descriptive information regarding the short-term clinical course. Median WBC count increased at 24 h after surgery, whereas median TP and ALB concentrations decreased. These laboratory changes were secondary observations, and their clinical significance could not be established from this case series.

Several limitations should be acknowledged. This study was limited by its retrospective design, small sample size, and single-center setting. The absence of a comparison group undergoing conventional PCCL or open cystotomy prevented assessment of the relative safety, efficiency, or clinical benefits of the technique. The study was designed primarily to evaluate clinical feasibility rather than to test differences between procedural constraint categories. Accordingly, the low- and high-constraint categories were used descriptively, and their small and unequal sample sizes limit the interpretation of category-specific outcomes. In addition, postoperative inflammatory and stress-related biomarkers were assessed only at 24 h after surgery, limiting evaluation of their temporal responses. Furthermore, the weighting and cutoff values of the exploratory composite constraint framework were empirically derived and have not been formally validated. Therefore, the framework should be regarded as a descriptive approach to characterizing case heterogeneity rather than as a predictive scoring system.

In conclusion, cannula-free single-port PCCL using a 5-mm operative hysteroscope was successfully completed in all 10 dogs, with complete stone removal achieved in every case. The included dogs presented varying body-related and disease/anatomy-related procedural constraints, and successful completion was achieved even in cases with multiple concurrent constraints. These findings provide preliminary support for the clinical feasibility of the technique across the range of procedural conditions represented in this case series. Further studies involving larger and more diverse populations are needed to better characterize its clinical outcomes.

List of abbreviations

PCCL: Percutaneous cystolithotomy

ALB: Albumin

CRP: C-reactive protein

CSU-CAP: Colorado State University Canine Acute Pain Scale

IQR: Interquartile range

TP: Total protein

WBC: White blood cell

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Authors' contribution

S.P. conceived and designed the study. J.K. performed the surgical procedures and collected the clinical data. S.P. , J.M. analyzed and interpreted the data and drafted the manuscript. J.K, J.M., G.J. and S.P. contributed to manuscript editing and revision. All authors critically revised the manuscript and approved the final version.

Ethics declaration

Ethics approval and consent to participate

Ethical approval was not required because all clinical procedures and data collection were performed as part of routine veterinary diagnostic evaluation and treatment. Written informed consent was obtained from the owners for the participation of their animals in this study.

Consent for publication

Not applicable.

Conflict of interest

The authors declare that they have no competing interests.

Availability of Data and Materials

The datasets used and/or analysed during the current study available from the corresponding author on reasonable request.

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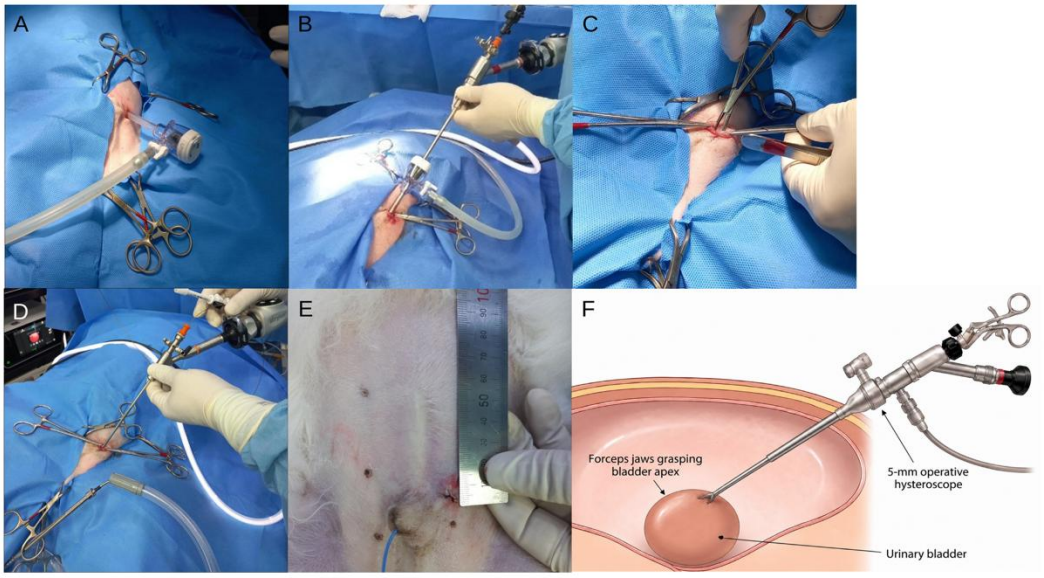
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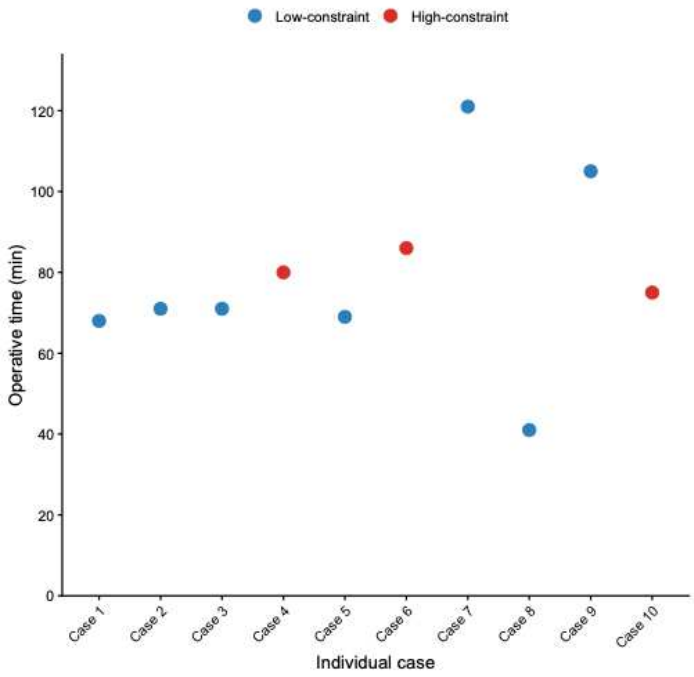
Fig. 1 Operative sequence and key technical features of the cannula-free single-port percutaneous cystolithotomy technique



(A) Initial 5-mm trocar placement for laparoscopic access. **(B)** Operative hysteroscope insertion and bladder apex elevation. **(C)** Trocar removal, bladder fixation with a craniocaudal stay suture and bilateral mosquito forceps, and creation of the cannula-free working window. **(D)** Direct insertion of an 8/9.8-Fr pediatric operative cystoscope through the cannula-free cystotomy for stone retrieval. **(E)** Postoperative appearance of the surgical access site after routine skin closure. **(F)** Schematic illustration of hysteroscope-mediated bladder elevation using micro-forceps passed through the integrated working channel.

Fig. 2 Operative time according to constraint group.

Operative times for individual dogs undergoing cannula-free single-port percutaneous cystolithotomy. Blue circles indicate low-constraint cases and red circles indicate high-constraint cases. Constraint categories are shown descriptively and were not used for inferential



group comparison.

Fig. 3 Postoperative pain and recovery outcomes following cannula-free single-port percutaneous cystolithotomy in 10 dogs. (A) Individual pain scores at 6 and 24 h after surgery, with paired measurements connected for each dog. (B) Time to sternal recumbency and (C) time to standing after anesthesia. Blue and red circles indicate low- and high-constraint cases, respectively.

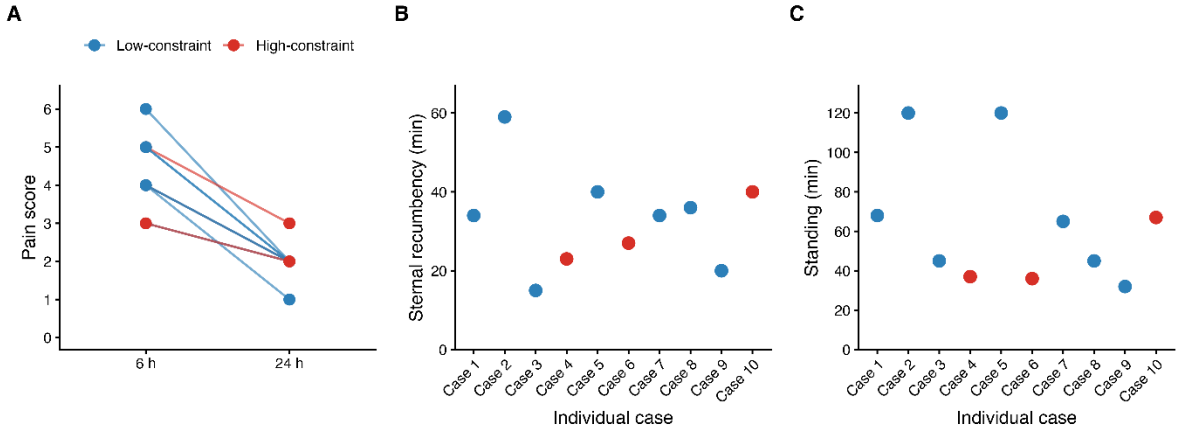
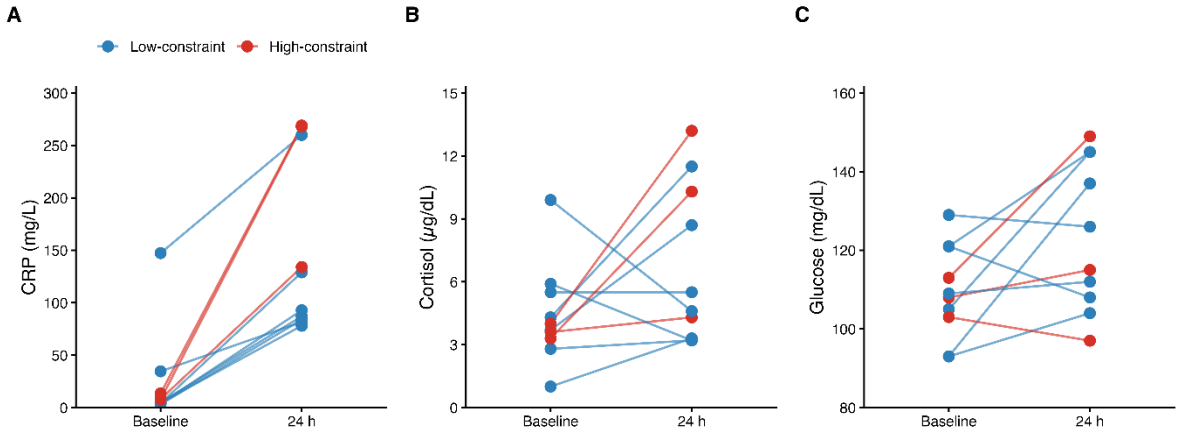


Fig. 4 Perioperative inflammatory and stress-related biomarker responses in 10 dogs undergoing cannula-free single-port percutaneous cystolithotomy. Individual concentrations of (A) C-reactive protein (CRP), (B) cortisol, and (C) glucose are shown at

400 baseline and 24 h after surgery. Grey lines connect paired measurements from the same dog.

401 Blue and red symbols indicate low- and high-constraint cases, respectively.



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403

404 **Table 1.** Baseline characteristics and procedural constraint profiles of the included dogs

Variable	All dogs (n=10)	Low-constraint (n=7)	High-constraint (n=3)	Unit/definition
Baseline characteristics				
Body weight	5.60 [3.95–7.60]	6.70 [5.60–8.25]	3.00 [2.28–3.70]	kg
Body condition score	4.50 [4.00–6.00]	5.00 [4.00–6.00]	3.00 [3.00–4.50]	1–9
TG/BW	6.95 [5.61–9.35]	5.70 [5.18–6.95]	12.00 [10.78–13.37]	cm/kg
BL/BW	6.43 [5.53–9.24]	6.12 [5.17–6.43]	9.67 [8.81–15.09]	cm/kg
Procedural constraint profile				
Fibrosis/adhesion	2 (20.0%)	0 (0.0%)	2 (66.7%)	n (%)
Previous surgery	7 (70.0%)	5 (71.4%)	2 (66.7%)	n (%)
Anatomical distortion	3 (30.0%)	0 (0.0%)	3 (100.0%)	n (%)
Composite constraint score	2.00 [2.00–3.50]	2.00 [1.50–2.00]	4.00 [4.00–4.50]	0–6

Continuous variables are presented as median [interquartile range], and categorical variables as number (%). Composite constraint scores of 0–2 were categorized as low-constraint and scores ≥3 as high-constraint. Constraint categories were used descriptively to characterize case heterogeneity rather than as groups for inferential comparison. BW, body weight; BCS, body condition score; TG/BW, thoracic girth-to-body weight ratio; BL/BW, body length-to-body weight ratio.

Table 2. Stone characteristics according to constraint group.

Variable	All dogs (n=10)	Low-constraint (n=7)	High-constraint (n=3)
Bladder involvement, n (%)	10 (100.0%)	7 (100.0%)	3 (100.0%)
Urethral involvement, n (%)	1 (10.0%)	1 (14.3%)	0 (0.0%)
Number of stones, median [IQR]	4 [1.25–18.25]	7 [4–36]	1 [1–1.5]
Largest stone diameter, mm, median [IQR]	8.7 [7.25–11.75]	8.0 [6.1–9.7]	30.0 [21.0–32.0]

Continuous variables are presented as median [interquartile range], and categorical variables as number (%). Constraint categories are presented descriptively to characterize the heterogeneity of the included cases and were not used for inferential group comparisons.

Table 3. Perioperative hematologic and biochemical profiles

Analyte	Baseline, median [IQR]	24 h, median [IQR]	Unit
HCT	47.25 [44.95–50.73]	44.60 [37.60–50.30]	%
WBC	9.30 [7.77–10.24]	13.60 [11.38–19.48]	$\times 10^3/\mu L$
PLT	289.00 [196.50–394.50]	254.50 [194.00–288.25]	$\times 10^3/\mu L$
BUN	19.50 [12.63–22.00]	8.95 [6.68–17.30]	mg/dL
CREA	0.75 [0.63–1.08]	0.75 [0.55–0.80]	mg/dL

ALT	91.00 [76.75–147.00]	77.50 [37.75–98.75]	U/L
TP	7.10 [6.88–7.28]	6.45 [6.08–6.83]	g/dL
ALB	3.45 [3.18–3.68]	2.90 [2.73–3.08]	g/dL

Values are presented as median [interquartile range]. HCT, hematocrit; WBC, white blood cell count; PLT, platelet count; BUN, blood urea nitrogen; CREA, creatinine; ALT, alanine aminotransferase; TP, total protein; ALB, albumin.