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Field study on clinical, surgical and economical assessments of urine retention in calves

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ABSTRACT

Urine retention is a prevalent and economically significant condition among male calves, particularly in developing countries where ruminants serve critical agricultural and socio-economic roles. This study aimed to clinically, surgically, biochemically, and economically assess obstructive urolithiasis in male calves, evaluating the efficacy and feasibility of various surgical interventions. Seventeen male calves aged 1–12 months and six apparently healthy calves were categorized into three groups: healthy controls (n=6), calves with intact distended bladders (n=5), and those with ruptured bladders (n=12). Clinical examinations and biochemical profiling were conducted preoperatively. Surgical interventions included pre-scrotal urethrostomy for intact bladders and cystoplasty with dorsal urethrotomy for ruptured bladders. Results indicated that bladder rupture was associated with younger age, lower body weight, and delayed urine retention. The sigmoid flexure was the predominant site of obstruction, with clinical signs varying by bladder status. Seasonal patterns indicated a spring peak in incidence, linked to nutritional and hydration shifts. Biochemically, ruptured cases exhibited marked elevations in urea, creatinine, uric acid, potassium, phosphorus, and magnesium levels, reflecting systemic derangement. Postoperative complications were minimal but more frequent in ruptured cases. The majority of the stones were calcium carbonate and phosphate. Stone size and volume positively correlated with calf body weight, suggesting dietary and metabolic influences. Surgical resolution, combined with targeted medical therapy, proved effective in restoring urinary function and preventing recurrence or mortality. The study underscores the importance of early diagnosis, surgical intervention, and preventive strategies such as dietary adjustments and urine acidification to mitigate recurrence and avoid economic losses.

Introduction

Especially in ill-developed countries, ruminants are considered as an economically important livestock species; play a significant role through contributions in many social and cultural aspects; represent a principle source of meat and milk; and act as a vital supply of valuable work animals, as they are used as draught animals in crop fields (Nanda and Nakao, 2003; Perera, 2008; Desta, 2012; Arefaine and Kashwa, 2015).

One of the most important surgical affections of this important species is urine retention by urinary stones, and although these stones are formed in both males and females, usually it is a challenging problem in males only as its treatment in males is an expensive issue; it causes significant morbidity in young calves and feedlot herds, and high mortality in affected animals when surgical treatment decision is delayed; in addition to that some treatment options have a negative impact on bulls' ability to reproduce successfully (Saharan *et al.*, 2020; Grissett, 2021).

Urine retention as a result of uroliths has been reported in numerous countries, it resulted in significant economic burden (Kushwaha *et al.*, 2009; Devadevi and Chandran, 2019), and it ranked as the fifth most common cause of death in feedlots (Makhdoomi and Gazi, 2013). The process of formation of urinary calculi is complex and its formation is multifactorial as it involved a number of physiological, nutritional, and managemental factors; like diet (heavy concentrate low roughage diets, excess sodium bicarbonate in the diet, vitamin A deficiency and hyper vitaminosis D), age, sex, breed, genetic makeup, season, soil, water (dehydration, limited water intake, mineralized artesian water, or alkaline water supplies), hormonal levels, and infection, (Andrews *et al.*, 2008; Gugjoo, *et al.*, 2013; Sutradhar *et al.*, 2018).

These urinary stones or uroliths may be embedded anywhere in the urinary tract, from the renal pelvis to the glans penis, unfortunately, in bovines, the distal portion of the sigmoid flexure and the glans penis are the most frequently obstructed areas (Sharma and Singh, 2001; Tamilmahan *et al.*, 2014). Such condition of urethral obstruction eventually results in bladder distention, abdominal pain and signs of colic, and if the problem is not resolved, either the urethral or the bladder will undergo rupture, which is usually a fatal condition because of toxemia, septicemia, uremia and/or fibrinous peritonitis (Abdel-Fattah and Sedeek, 2005; Fazili *et al.*, 2012).

The recorded clinical symptoms varied according to the duration of the obstruction, the nature of obstruction, and the status of the urethra and the urinary bladder (Janke *et al.*, 2009). The main points for diagnosis of this affection include case history, clinical signs, physical examination, and ultrasonography (Makhdoomi and Gazi, 2013).

Treatment of obstructive uroliths relies mostly on surgery because medical therapy alone, urine acidification and analgesics are rarely successful (Fecteau, 2022), and when the surgeon has to establish a treatment plan for affected calves, many factors should be kept in consideration like the intended use of the calf, the integrity of urinary tract, the location of obstruction, and the financial restrictions (Grissett, 2021). The main purpose of this work was to clinically, surgically, laboratory, and economically evaluate the usefulness of the surgical interventions adopted to solve urine retention problems in calves and to determine their economic feasibility for both the Customer and the national economy.

Materials and methods

Ethical Approval

All sample collection and surgical procedures were conducted in full compliance with the guidelines of the El-Minia University Animal Ethics Committee (Approval No. IRB-FVM-MU-2025-123).

Animals

The present study was conducted within the Minia Governorate, encompassing various districts including El Idowa, Bani Mazar, Samalut, Minia City, Abu Qurgas, and Mallawi. place animals' examination was performed across multiple settings: the Department of Clinical Surgery at

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the Faculty of Veterinary Medicine, Minia University; private veterinary clinics; and through veterinary medical convoy programs. The research was carried out over a two-year period, extending from February 2022 to February 2024. Seventeen clinical cases of non-castrated male calves, aged 1 to 12 months, exhibiting urine retention with signs such as anuria, discomfort, or depression were examined (Fig. 1). A control group of six apparently healthy, age-matched calves were included for biochemical comparison. Based on clinical findings, the calves were categorized into three groups: Group A (healthy control, n = 6), Group B (urine retention with intact distended bladder and pulsed urethra, n = 5), and Group C (urine retention with ruptured bladder, n = 12). Intact distended bladder and pulsed urethra group (mean weight 180 kg, mean duration of urine retention 2.20 days). Ruptured urinary bladder (109.16 kg, 6.58 days).

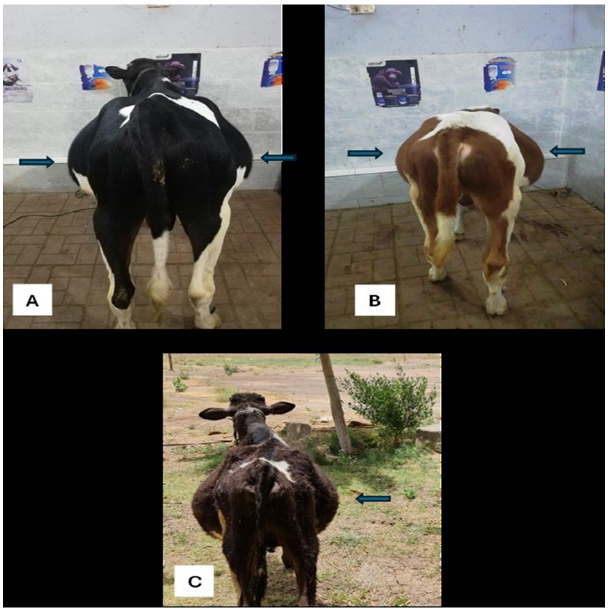

Fig. 1. A, B, C. The characteristic pear-shaped distension of the abdomen.

Clinical Examination

Upon admission, comprehensive case histories were obtained for each calf, focusing on factors such as age, weight, diet, water availability, geographical location, season and clinical signs preceding admission. Particular attention was given to the duration of urine retention and any history of medications or digestive issues. Following history collection, calves underwent full clinical examinations, including vital signs (Jackson and Cockcroft, 2002) and targeted assessment of the urinary system. Efforts were made to identify the location of urinary obstruction through penile palpation with special attention to the sigmoid flexure and retrograde catheterization under pudendal nerve block. The condition of the bladder intact or ruptured was determined using clinical signs, palpation, percussion, and confirmatory abdominocentesis when necessary (Cockcroft and Jackson, 2004).

Sampling

Following clinical examination and preliminary diagnosis, blood samples (5 mL) were collected from the jugular vein of affected calves using sterile, anticoagulant-free tubes. The samples were centrifuged to separate clear, non-hemolyzed serum, which was stored in sterile tubes for pre-surgical biochemical analysis. Urinary stones, when accessible, were removed aseptically during surgery, washed with sterile distilled water to remove debris, and air-dried at room temperature for further analysis.

Biochemical analysis

Serum levels of total proteins, albumin, urea, creatinine, uric acid, sodium, potassium, phosphorus, chloride, magnesium, and calcium were determined spectrophotometrically by Sinothinker SK3002B semi-automatic chemistry analyzer (Sinothinker, China). The analyses were conducted with commercial diagnostic kits, including Spinreact kits (Spinreact, Spain) and MG kits, following standardized procedures (Latimer, 2011).

Stone analysis

Urinary calculi collected aseptically during surgical procedures underwent macroscopic examination to document their physical characteristics. Each stone's weight was measured using a precision balance, while the stone's volume was determined by submerging it in a balloon filled with water and measuring the displacement using ultrasonography with a linear probe 3.5/ 5MHz. The stones were then finely ground using a clean, dry porcelain mortar to obtain particle sizes suitable for chemical composition analysis, which was performed using renal calculi diagnostic kits (Diamond Diagnostics, USA).

Surgical interferences

The operated calves were managed medically prior to surgery, as they were first rehydrated with an appropriate volume of saline solution, then they were prepared for anesthesia and surgery. At first the operated calf was S.C injected by atropine sulphate in a dose rate 0.2 mg/kg then after 10 min, sedation was achieved by 0.2 mg/kg intramuscular xylazine HCl 2% (Xyla-Ject®, ADWIA Pharmaceuticals Co., 10th of Ramadan City, Egypt). Analgesia was provided through a second dose of epidural injection (according to need), consisted of 8–12 mL of 2% lidocaine HCl (Debocaine®, 20mg/ml, the Arab Company, Obour City, Egypt), and linear infiltration at the surgical site (Hall and Clarke, 1983). Seat of surgery was aseptically prepared, then the animals were positioned in right lateral recumbency, with the left hind limb flexed, slightly abducted, and pulled cranio-dorsally to fully expose the perineal, pre-scrotal, and prepubic regions for the different procedures.

Surgical Interferences in Intact Urinary Bladder (Group: B)

Pre-Scrotal Urethrostomy

The pre-scrotal urethrostomy procedure (Fig. 2) was applied to four calves that had stones at the sigmoid flexure, and it involved a longitudinal para-median skin incision approximately 5 cm in length. This incision was made 5 cm cranial to the neck of the scrotum and 2–4 cm lateral to the midline at the scroto-preputial junction. The penis was carefully exteriorized by blunt dissection, and the obstructing stone was identified at the ventral curvature of the sigmoid flexure. The insertion of the retractor penis muscle was advanced and anchored to the subcutaneous tissue at the skin incision using chromic catgut sutures. This step straightened the sigmoid flexure and prevented protrusion of the glans penis through the prepuce.

A 2 cm longitudinal urethrotomy was then performed to facilitate stone removal. The patency of the urethra was evaluated in both directions, then urethral mucosa was sutured to the skin by silk in a simple interrupted pattern to establish the urethrostomy. The remaining unrequired portions of the skin incision, anterior and posterior to the urethrostomy site, were closed with interrupted silk sutures to complete the procedure (Abdelrhman *et al*., 2012).

Stone removal

One calf was sedated by intramuscular administration of xylazine HCl 2% (0.2 mg/kg). Following sedation, the penis was carefully manipulated, and the obstructing stone was manually extracted from glans penis by gentle fingers pressure. Preputial wash with povidine iodine for three successive days was adopted.

Fig. 2. A; The pre-scrotal longitudinal para-median skin incision. B; ventral urethrotomy to remove the urolith. C; The urethral mucosa was sutured to the skin using No. 2 silk in a simple interrupted pattern to establish the urethrostomy. D; urination of animal after surgery.

Surgical interferences in ruptured urinary bladder group (Group C)

Laparotomy and dorsal urethrotomy

This surgical procedure was performed in 12 cases involving stone at the sigmoid flexure. A pre-pubic oblique incision (10–12 cm) was performed at the prepubic region and extended cranio-ventrally toward the midline anterior to the rudimentary teats. A blunt dissection was carried out at the ventral commissure of the incision, subcutaneously, to access the preputial sheath, and enabling exteriorization of the penis, which was bluntly dissected and moistened by saline. The calculus was identified and the dorsal urethrotomy technique was applied according to (Abdel-Fattah and Sedeek, 2005). A tourniquet was applied proximal to stone to induce engorgement of the dorsal penile veins followed by another tourniquet distal to the stone, then an incision was made on the dorsal penile surface to separate the engorged veins to expose and incise the tunica albuginea of corpus cavernosum, and advanced deeper to reaching the stone after incising tunica albuginea of corpus spongiosum and urethral mucosa (Fig. 3A & B).

A mosquito forceps was inserted via the incision to capture the stone (Fig. 3. C & D), then a lubricated Ryles tube (No. 8–12 according to animal weight), supported by a sterile flexible stainless-steel stylet, was advanced retrograde toward the urinary bladder, gentle pressure by gloved figure per rectum was recommended until the Ryles tube cross the urethral recess (Sedeek *et al*., 2009; Seddek and Bakr, 2013) then was advanced distally, to confirm the absence of additional stones. Subsequently, the dorsal penile incision was closed using a cross-mattress suture pattern with polyglactin 910 sutures following the removal of both tourniquets (Fig. 3E).

Prior to repositioning the penis to its original position, the preputial incision was sutured to close the split (Fig. 3 F). The abdominal wall and peritoneum were incised, and urine was gradually evacuated. The bladder was cleaned, and the Ryles tube was advanced from the bladder incision towards the external urethral orifice (Fig. 3 G & H). The peritoneal cavity was lavaged with an isotonic solution. The stylet was removed, and the feeding port of the Ryles tube was excised. A 10 cm segment of the Ryles tube was fenestrated and coiled within the bladder. Following this, the bladder, peritoneum, and abdominal wall (Fig. 3 I & J) were sutured in routine manner (Bouré *et al*., 2005). The distal end of the Ryles tube was hidden behind the preputial orifice and fixed to the preputeal skin with a single silk stitch.

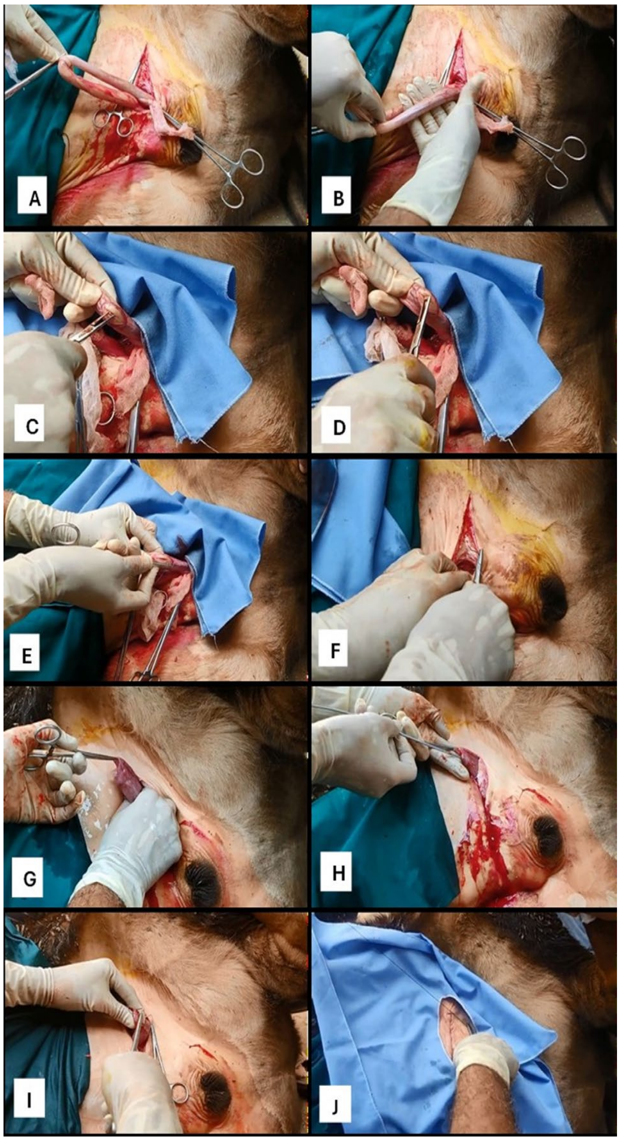

Fig. 3. A, B; Dorsal aspect of the calf's penis prior to the dorsal urethrotomy technique, illustrating the placement of the proximal and distal tourniquets along with the visualization of the dorsal penile veins. C, D; Dorsal aspect of the calf's penis during the dorsal urethrotomy procedure, showing the incision of the tunica albuginea of the corpus cavernosum and the capture of the urolith. E; Suturing of the dorsal penile incision using polyglactin 910. F; suturing of the preputial incision. G; The bladder demonstrating urine seepage through the defect on its ventral surface. H; Placement of a Ryles tube, reinforced with a multifilament flexible stainless-steel stylet, into the bladder wound. I; Suturing of bladder by chromic catgut. J; suturing skin by silk.

Post-operative care

Following surgery, the animals received an intravenous infusion of appropriate fluids to ensure the kidney function normality, to maintain the hemodinamic stability, and to support recovery. Systemic antibiotic (Pen&Strep®, Norbrook Co., N. Ireland, 1 mL/25 kg body weight) was administered parenterally for five consecutive days to control infection. Additionally, meloxicam (0.5 mg/kg body weight; Metacam, Boehringer Ingelheim GmbH, Ingelheim, Germany) was given for three successive days postoperatively to manage pain and inflammation. Wound care was conducted daily, by mean of povidone-iodine for disinfection to promote healing and minimize the risk of complications.

The owners were instructed to provide the animal with 5 g of salt and 200 mg/kg of ammonium chloride orally each day for one month and to ensure that the calf had unrestricted access to fresh water. In cases managed with urethrotomy, the Ryles tube was removed 3–5 days post-surgery, and silk sutures were removed between 10 and 12 days after the procedure.

The operated calves were monitored for a minimum period of two months. Follow-up was conducted through in-person visits for cases located nearby, while phone calls were used to assess those in rural or remote areas. Any complications observed during this period were carefully documented.

Feasibility study

According to Abdel-Fattah and Saleh (2005) this feasibility Study was performed in different villages in El Minya province during the period from October 2023 to September 2024.

Calves with urine retention were subjected to clinical evaluation before Surgical intervention to check their general health condition to detect whether they were fit for surgery or not. All cases that were expected not to withstand surgery were excluded from this study.

The recorded data included breed, age, weight, and percentage of success of surgical operations that were detected by recording the percentage of animal recovery and ability to restore its physiological activities.

The estimated price of cattle and buffaloe calves Prior to affection (A), was detected according to the average prices of the Calves in the animal markets of the Study location.

The method of determination of calf price depends on the breed, age, weight, advantages, and disadvantages of each calf and the aim of breeding. It is worth noting that the majority of the calves in this study were native breeds (baladi or mixed).

The estimated price of the diseased calves (B) was detected according to the average prices recorded by the emergency-case butchers in each location of the province, according to age, weight of urine retained calves, whether the animal was live or already emergency slaughtered at the time of selling, and whether the day of slaughtering coordinated with the acceptance of meat marketing or not.

The total cost of surgery (C) included the cost of the prescription, surgeon, and assistants. The cost of the required medications was calculated according to the price of these medical materials in the pharmacies, and the fares of surgeons and assistants were detected according to the average veterinarian fares in every location. From the data obtained, some of the undiscounted measurements of economical feasibility were calculated, which included Short-run expected revenue (D=A-B), expected economical net revenue after subtraction of the cost of surgical intervention (H=D-C), Net revenue for one L.E investment in surgical intervention (O=H/C), and benefits/Cost ratio (L=D/C).

Statistical Analysis

The statistical analysis in this study was conducted using IBM SPSS software version 20.0 (IBM Corp., Armonk, NY). Qualitative data were presented as frequencies and percentages, while quantitative data were expressed as means and standard deviations. For statistical significance between the groups, post-hoc pairwise comparisons were performed. Statistical significance was determined at the 5% level ($p < 0.05$).

Results

Clinical Observations

The observed clinical signs in Groups: B (intact bladder) included; signs of loss of appetite or anorexia, abdominal pain manifested by grinding of the teeth, restlessness, kicking toward the belly, and straining; signs of frequent unsuccessful efforts of urination that was accompanied by frequent clear urethral pulsation, tail switching, and dribbling of urine, which was tinged with blood in some calves; and protrusion of the anal mucous membrane in some animals during the severe straining.

In Group: C (ruptured bladder), animals exhibited; signs varying degrees of dehydration manifested by dullness, anorexia, severe depression in some calves who tended to lay down, sunken eyes, and dry muzzle; signs of uremia and toxemia in the form of conjunctival congestion, and urinephrous breath. On the contrary to intact urinary bladder group, signs of colic could not be detected.

Clinical characteristics of calves with urine retention in the studied groups

Group B: The Rumen either had hypomotility or stasis with hard contents, whereas the heart rate, respiration rate, and body temperature were normal in 3 calve and slightly elevated in 2 calves. Finger rectal palpation showed that there was urethral pulsation.

Group C: Examination of the eye and the muzzle revealed that the calves had sunken eyes, conjunctival congestion and dry muzzle. rumen motility was absent, the heart had tachycardia, calves had polypnea, and there was subnormal rectal temperature in 5 cases. Inspection of the abdominal contour from behind revealed a pear-shaped appearance of the distension abdomen (Fig. 1). Diagnostic procedures like abdominocentesis revealed the presence of free urine in the abdominal cavity. On percussion, a detectable fluid wave was identified. Smelling of breath revealed uremic odor.

Stone location

Examination of claves by palpation and by retrograde catheterization under the effect of pudendal nerve block showed that most stones were located in the sigmoid flexure, accounting for 4 calves (80% of cases) in the intact bladder group and 10 calves (83.3%) in the ruptured bladder group. Stones in the glans penis were identified in 1 calf (20% of cases) in the intact bladder group, while the neck of the bladder was occluded in 2 calves (16.7%) of the ruptured bladder cases.

Status of the urinary bladder

The intact bladder group had no signs of tearing, whereas 6 calves (50% of cases) in the ruptured bladder group healed spontaneously, and 6 calves (50%) remained ruptured.

Seat of urinary bladder rupture

Among cases with ruptured urinary bladders, the cases with ventral ruptures (8 calves- 66.67% of cases) greatly exceeding those with dorsal rupture (4 calves - 33.33%).

Surgical interferences

Postoperative complications included wound edema in one calf that underwent pre-scrotal urethrostomy. Additionally, wound edema and cystitis were observed in two calves following laparotomy and dorsal urethrotomy.

Evaluation of laboratory profiles across different urine retention groups and control

As shown in Table 1, serum concentrations of urea, creatinine, and uric acid were elevated in both study groups compared to the control group. In the intact urinary bladder group, the increase in urea was not statistically significant ($p > 0.05$), whereas the elevations in creatinine and uric acid were significant ($p < 0.05$). In the ruptured urinary bladder group, all three parameters urea, creatinine, and uric acid were significantly higher ($p < 0.05$) than those in the control and intact bladder groups, with this group exhibiting the highest values.

Serum levels of potassium, phosphorus, and magnesium were also increased across the study groups relative to the control. However, a statistically significant elevation ($p < 0.05$) was observed only in the ruptured urinary bladder group for all three electrolytes (K, P, and Mg) (Table 1).

All study groups demonstrated mild reduced serum albumin levels (hypoalbuminemia) in comparison to the control group, although the decrease did not reach statistical significance. Total protein concentrations remained comparable among all groups (Table 1). In contrast, calcium and chloride levels were decreased (hypocalcemia and hypochloremia) in both study groups relative to the control, but these differences were not statistically significant ($p > 0.05$). Similarly, serum sodium levels showed minimal variation, with no significant differences between groups ($p > 0.05$) (Table 1).

Table 1. Evaluation of laboratory profiles across different urine retention groups and control.

	Control group (n.=6)	Intact urinary bladder group (n.= 5)	Ruptured urinary bladder group (n.= 12)
Total protein (g/dL)	7.34 ± 0.52^{a}	6.02 ± 0.78^{a}	6.63 ± 1.08^{a}
Albumin (g/dl)	3.86 ± 0.24^{a}	3.34 ± 0.18^{ab}	3.50 ± 0.45^{ab}
Urea mg/dl	54.90 ± 9.04^{a}	153.27 ± 53.9^{a}	279.07 ± 88.40^{b}
Creatinine (mg/dl)	1.07 ± 0.07^{a}	4.18 ± 1.03^{b}	9.09 ± 4.41^{c}
Uric acid (mg/dl)	4.91 ± 0.52^{a}	7.77 ± 0.70^{b}	10.63 ± 2.29^{c}
Na (mEq/L)	138.60 ± 1.70^{a}	134.05 ± 11.28^{a}	133.08 ± 12.14^{a}
K (mmol/L)	4.40 ± 0.52^{a}	6.21 ± 2.90^{ab}	7.07 ± 1.80^{b}
P (mg/dL)	4.14 ± 0.34^{a}	6.10 ± 2.14^{ab}	8.96 ± 3.94^{b}
Cl (mmol/L)	101.7 ±2.60^{a}	96.73 ± 8.14^{a}	92.27 ± 10.90^{a}
Mg (mg/dL)	2.11 ± 0.20^{a}	3.06 ± 0.65^{ac}	3.92 ± 0.67^{b}
Ca mg/dL	9.40 ± 0.43^{a}	7.70 ± 1.21^{a}	7.96 ± 1.56^{a}

Data are expressed as Mean ± SD (standard deviation). In the same raw, values with different superscript letters have significant variations from each other $p < 0.05$.

Comparative analysis of stone characteristics between intact and ruptured urinary bladder groups.

Physical characteristics

Calcium phosphatic calculi were gray-white color, a smooth surface, brittle, and easily fragmentable. In contrast, calcium carbonate calculi were typically round, hard, and chalky, with colors ranging from white to reddish-brown.

Types of stone

calcium carbonate stones were identified in 60% (3/5) of the intact urinary bladder group and 75% (9/12) of the ruptured urinary bladder group (P = 0.53P). Calcium phosphate stones accounted for 40% (2/5) in the intact urinary bladder group and 25% (3/12) in the ruptured urinary bladder group. Neither stone type demonstrated statistically significant differences between the groups (P > 0.05) (Fig. 4).

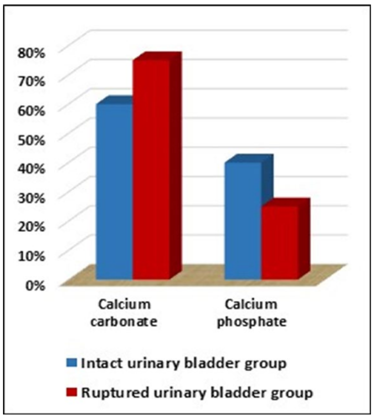

Fig. 4. Distribution of type of stone among studied groups.

Table 2. Comparative distribution, clinical outcomes, and economic feasibility of surgical interventions for urine retention in calves.

NO	Animal	Average age	Average weight	Cases	Surgical affections	Surgical interferences	A Estimated price of the calves prior to affection	B Estimated price of the calves after affection	C Total Cost of Surgical Interventions*					D Short run expected revenue D = A-B	H Expected net revenue after subtraction of surgical cost H = D - C	O Net revenue for one L.E investment in surgery O = H/C	L Benefits cost ratio L=D/C
									Materials	%	Fares	%	Total 100%				
1	Cattle calves	3 months	110 Kg	16	Urine retention with intact U.B	Urethrostomy	28000	7000	700	53.8	600	46.2	1300	21000	19700	15.2	16.2
2	Buffaloe calves	2 months	85 Kg	8	Urine retention with intact U.B	Urethrostomy	23000	5000	600	50	600	50	1200	18000	16800	14	15
3	Cattle calves	2.5 months	90 Kg	13	Urine retention with ruptured U.B	Cystoplasty and dorsal urethrotomy	26000	6000	900	45	1100	55	2000	20000	18000	9	10

*Egyptian Pound (L.E) was the basic unit for financial calculation in this study.

Correlation among calves' weight, volume and size of stones

Calves' weight vs. stone volume (Cm^3)

The correlation coefficient between calves' weight and stone volume was 0.455, which is a moderate positive correlation, with a p-value of 0.034. Since the p-value is less than 0.05, the correlation is statistically significant.

Calves' weight vs. stone size (g)

The correlation coefficient between calves' weight and stone size was 0.490, with a p-value of 0.021, the p-value is below 0.05. There was a significant positive correlation between calves' weight and stone size.

Feasibility study

The study revealed the evaluation of a group of undiscounted measurements of economical feasibility of surgical inventions that were performed on a group of cattle and buffaloe calves (37 cases) were suffered from urine retention (Table 2), which threatens the life of the calves and leads to its death. Consequently, this leads to huge financial losses, whether in the short or long term, which negatively affects the economics of farmers.

Discussion

This study analyzed the age distribution of calves affected by urolithiasis, revealing that most cases occurred in calves ≤6 months old (Fazili and Ansari, 2007; Gugjoo, *et al*., 2013; Bayoumi and Attia, 2017). Notably, calves with ruptured bladders had a lower mean age compared to those with intact bladders, suggesting that younger calves are more vulnerable to both obstruction and its severe complications (Seif *et al*., 2007; Amarpal *et al*., 2013).

This increased susceptibility in younger calves is likely due to a combination of physiological and management-related factors. The peak incidence of obstruction aligns with the 2–6 month age range, coinciding with early weaning and a shift to phosphorus-rich, calcium-poor diets such as wheat or rice bran (Mangotra *et al*., 2016). Additionally, reduced water intake during colder months and lower roughage consumption post-weaning may contribute to higher urinary concentration and decreased phosphate buffering, promoting urolith formation (Singh, *et al*., 2005; Amarpal *et al*., 2013).

This study demonstrated that longer urine retention is associated with more severe urological conditions in calves. Calves with ruptured bladders had the longest retention times, while those with intact bladders had the shortest, supporting previous findings by Abdallah *et al*. (2021), who noted that brief anuria (1–2 days) often indicates milder cases, whereas prolonged retention (≥3 days) suggests complications like bladder rupture and uroperitoneum.

The health status of affected calves also deteriorated with longer urine retention due to metabolic disturbances caused by uroabdomen, consistent with observations by Singh *et al*. (2014). Additionally, delays in veterinary care often due to lack of owner awareness or misdiagnosis contribute to worse outcomes. Rafee *et al*. (2015) and Bayoumi and Attia (2017) reported that many calves are only brought for treatment after several days of anuria, increasing the risk of rupture and systemic complications. Rafee *et al*. (2015) observed a clinical peak by the third day of retention, after which case numbers declined due to disease progression and mortality.

The study revealed that calves with lower body weight were more likely to suffer severe forms of obstructive urolithiasis, including bladder rupture. This may be due to anatomical and physiological limitations such as narrower urethral lumens and reduced compensatory capacity (Amarpal *et al*., 2013; Singh *et al*., 2014). Additionally, lower weight in affected calves may reflect disease progression, as prolonged urine retention leads to anorexia, dehydration, and catabolism, contributing to further weight loss and systemic decline (Bayoumi and Attia, 2017).

The results of this study showed that the most obstructive urolithiasis cases with or without ruptured bladder were high in some locations, and this attributed to poor management practices, low water quality and delaying treatment.

It is worth noting that the results obtained are consistent with those of Amarpal *et al*. (2013); Rafee *et al*. (2015) and Bayoumi and Attia (2017) who confirmed that spring is the peak season for occurrence of obstructive urolithiasis in calves followed by winter with minimal incidence in summer and fall, this is due to seasonal changes in hydration and diet.

In winter, limited water intake and calcium-rich forage, such as clover, promote concentrated urine and stone formation. During spring and summer, dehydration and high-concentrate, low-roughage feeding further exacerbate crystallization risk (Seif *et al*., 2007; Constable *et al*., 2017).

These findings highlight the importance of seasonally tailored preventive measures focused on hydration, balanced nutrition, and mineral management to reduce the incidence and severity of urolithiasis in young calves.

In this study, clinical diagnosis of obstructive urolithiasis in calves relied heavily on integrating patient history with observable clinical signs. Calves with intact bladders typically presented with anuria, colic, urethral pulsation, and unsuccessful straining to urinate, signs consistent with bladder distension and nociceptive activation, as reported by Mangotra *et al*. (2016), and Ismail (2018). The associated pain is attributed to increased intravesical pressure stimulating bladder wall stretch receptors (Biswas and Saifuddin, 2015).

Conversely, calves with ruptured bladders exhibited dullness, dehydration, and pear-shaped abdominal distension, without typical colic signs. These clinical features, supported by findings of free abdominal fluid and fluid wave on percussion, reflect the development of uroperitoneum and align with descriptions by Bayoumi and Attia (2017) and Abdallah *et al*. (2021). Pain reduction in such cases results from absence of bladder pressure due to urine leakage (Rafee *et al*., 2015), while progressive abdominal distension due to free flow urine within abdominal cavity, osmotic shifts, and peritonitis (Constable *et al*., 2017).

Across groups, elevated heart and respiratory rates were likely due to dehydration, stress, and uremic toxicity (Lavania *et al*., 1973; Bayoumi and Attia, 2017). Subnormal body temperatures observed in ruptured cases further indicate systemic dysfunction and toxemia linked to retained waste products (Constable *et al*., 2017).

This study identified the sigmoid flexure as the predominant site of urethral obstruction in calves due to its sharp S-shaped curvature that predisposes it to urolith retention (Fecteau, 2022; Mejia *et al*., 2022).

The predisposition of male calves to urethral obstruction is strongly influenced by anatomical features, including the long, narrow urethra and anatomically vulnerable segments such as the sigmoid flexure (Constable *et al*., 2017; Sutradhar *et al*., 2018). The distal flexure of the sigmoid flexure, particularly in young animals with narrow lumens, is especially susceptible to urolith impaction (Rogers, 2001).

The results explained that all calves with intact bladder showed no tearing or disintegration. Ventral rupture rate is higher than dorsal rupture due to the friction of the lower aspect of bladder with the pubic bone, a pattern consistent with Seif *et al*. (2007). Although ventral ruptures were more frequent, dorsal ruptures are associated with more favorable healing outcomes due to reduced urine extravasation and increased likelihood of adhesion formation near adjacent intestinal loops (Seif *et al*., 2007). Additionally, dorsal lesions often retain calculi or clotted blood within the bladder, aiding in spontaneous welding.

The current study assessed surgical approaches in calves with obstructive urolithiasis, classified based on bladder integrity. In the intact bladder group, pre-scrotal urethrostomy was the most performed procedure (80%). Minor postoperative complications, including wound edema, were observed, aligning with Slatter (2003) and Abdelrhman *et al*. (2012), who noted that pre-scrotal urethrostomy is associated with lower rates of stricture and urine scalding due to reduced tissue tension, more effective urine drainage and longer validity.

In contrast, calves with ruptured bladders underwent more invasive interventions, notably laparotomy with dorsal urethrotomy. Postoperative complications in this group, such as wound edema and cystitis, reflected the increased procedural complexity and systemic compromise typical of advanced cases. Dorsal urethrotomy was favored for its reduced risk of urethral rupture and better healing outcomes, as supported by Abdel-Fattah and Sedeek (2005) and Seif *et al*. (2007), who emphasized its anatomical advantages and avoidance of necrotic tissue in suturing.

In calves with an intact urinary bladder, urea levels increased non-significantly, while creatinine and uric acid showed statistically significant elevations. Conversely, calves with ruptured bladders exhibited markedly higher levels of all three biomarkers, indicating more severe systemic derangement. These findings align with previous research emphasizing the diagnostic utility of serum urea and creatinine as indicators of uremia associated with urolithiasis (Constable *et al*., 2017; Ismail, 2018).

The pathophysiology of elevated serum urea involves prolonged urinary retention, which promotes urea reabsorption across the urothelium (Sharma *et al*., 2006), and backpressure-induced reductions in glomerular filtration rate. This mechanism is further exacerbated in bladder rupture cases, where urea diffuses directly from peritoneal urine into circulation (Donecker and Bellamy, 1982).

Similarly, serum creatinine levels, particularly elevated in ruptured bladder cases, reflect renal dysfunction aggravated by backpressure and hydronephrosis (Singh, *et al*., 2005). Creatinine, a by-product of muscle metabolism, is normally excreted efficiently by healthy kidneys. Its elevation in ruptured bladder cases has been attributed both to impaired filtration and to passive diffusion from the peritoneal fluid into the bloodstream, at a slower rate than urea due to its larger molecular size (Donecker and Bellamy, 1982; Ismail, 2018). Given that creatinine levels are relatively unaffected by dietary intake, they are considered a more specific indicator of renal function compared to urea (Sockett *et al*., 1986; Carlson, 1990).

These findings are consistent with previous reports (Villar *et al*., 2003; Ismail, 2018), which highlight the significant diagnostic and prognostic implications of elevated nitrogenous waste in calves with urinary tract rupture, thereby emphasizing the importance of early detection and appropriate management.

The marked hyperkalemia in ruptured urinary bladder calves, consistent with previous reports linking urinary tract obstruction to elevated potassium levels (Sockett *et al*., 1986; Constable *et al*., 2017). This elevation likely results from passive diffusion of potassium-rich urine into the peritoneal cavity and subsequent systemic absorption (Donecker and Bellamy, 1982; Ismail, 2018). Although ruminants can excrete potassium through saliva, this compensatory mechanism appears insufficient in severe cases such as uroperitoneum (Sockett *et al*., 1986). Additional contributing factors include metabolic acidosis, reduced renal perfusion, and hemolysis (Makhdoomi and Gazi, 2013). The cardiotoxicity of hyperkalemia may be further aggravated by coexisting hypocalcemia and hyponatremia, both observed to varying extents in this study.

Hyperphosphatemia was another significant alteration, particularly in the ruptured bladder group, and has been attributed to reduced glomerular filtration rate (GFR) and peritoneal reabsorption of phosphate from urine (Varley, 1988; Ismail, 2018). Tissue hypoxia, resulting from urine retention and cellular energy imbalance, may also contribute by releasing intracellular phosphate (Sockett *et al*., 1986; George, *et al*., 2007). The concurrent hypocalcemia may be explained by the inverse relationship between calcium and phosphorus levels (Constable *et al*., 2017), as well as impaired calcium absorption due to vitamin D deficiency caused by renal dysfunction (Kaneko *et al*., 2008; Ismail, 2018).

Hypermagnesemia, observed significantly in ruptured bladder group, is notable and many earlier studies reported it in similar condition due to impaired tubular reabsorption (Sockett *et al*., 1986 and George *et al*., 2007). However, in the context of uroperitoneum, magnesium may follow the same absorption pathway as potassium and phosphorus, diffusing from the peritoneal cavity into the circulation (Ismail, 2018). The elevated magnesium levels observed here could also reflect reduced urinary excretion secondary to renal dysfunction (Shafik and Dirks, 1992).

Although hypochloremia was observed in affected calves, the differences were not statistically significant. Decreased serum chloride may result from several mechanisms, including sequestration of Cl^- in the gastrointestinal tract, especially under anorexic conditions, and diffusion of chloride into the peritoneal cavity (Makhdoomi and Gazi, 2013; Sockett, *et al*., 1986). In cases of uroperitoneum, the diffusion of chloride into the peritoneal space, where urine typically contains lower chloride concentrations, may explain its observed decrease (Donecker and Bellamy, 1982; Ismail, 2018).

Regarding sodium, the current study recorded no significant changes across groups, and this coincides with Sharma *et al*. (2005), but in contrast to the findings of Donecker and Bellamy (1982) and Sockett, *et al*. (1986), who documented hyponatremia in calves with ruptured bladder. The movement of sodium from the extracellular space into the peritoneal cavity, where urine has a lower sodium concentration, may account for this variability (Donecker and Bellamy, 1982; Ismail, 2018).

The current study found hypoalbuminemia across all affected groups compared to the control group, though without statistical significance. This reduction in serum albumin is linked to inflammation, fluid shifts, and decreased hepatic protein synthesis common outcomes in obstructive uropathies. Albumin, a negative acute-phase protein, decreases in response to pro-inflammatory cytokines like IL-1, IL-6, and TNF-α, which are often elevated due to uroperitoneum, infection, or tissue necrosis (Constable *et al*., 2017; Stockham and Scott, 2024). These factors inhibit albumin production, contributing to the overall decline in levels across all clinical cases (Ismail, 2018).

Interestingly, earlier studies by Mangotra *et al*. (2017) and Ismail (2018) found more severe hypoalbuminemia in calves with intact bladders, which they attributed to diminished albumin synthesis combined with less dehydration.

Calcium carbonate was identified as the predominant urolith type, accounting for 70.6% of cases. These findings are consistent with earlier reports suggesting a high prevalence of calcium carbonate stones in ruminants grazing on calcium-rich forages such as alfalfa and clover (Larson, 1996; Byers, 2020). Morphologically, calcium carbonate stones were round, dense, and chalky, often white to reddish-brown, while calcium phosphate calculi (29.4%) were gray-white, smooth, and brittle, as similarly described by Parkinson *et al*. (2019) and Byers (2020).

Stone formation was closely linked to urine pH, with alkaline urine favoring calcium carbonate and phosphate stone development. This observation supports earlier findings by Larson (1996) and Parkinson *et al*. (2019).

Dietary factors played a crucial role in stone formation. High-calcium, low-phosphorus diets, such as legume-rich rations, promote calcium carbonate stones, while cereal grain-based, phosphorus-heavy diets predispose animals to calcium phosphate and struvite calculi (Stratton-Phelps and House, 2004; Byers, 2020). Imbalanced calcium-to-phosphorus ratios below 2:1 is particularly risky.

Preventive strategies should focus on dietary management and urine acidification, with ammonium chloride supplementation recommended to reduce the risk of alkaline-associated stones (Parkinson *et al*., 2019; Cook, 2023).

Furthermore, the study revealed a statistically significant positive correlation between body weight and both stone volumes. This suggests that heavier calves may be more susceptible to larger and more voluminous calculi due to increased mineral intake and renal excretion associated with higher feed consumption and metabolic activity (Parkinson *et al*., 2019; Byers, 2020). Additionally, body weight may indirectly reflect cumulative exposure to lithogenic diets, supporting findings by Cook (2023) and Kumar *et al*. (2023) that link prolonged dietary imbalance with progressive stone formation. Larger stones in heavier animals also increase the risk of urinary obstruction, particularly in anatomically narrow regions like the sigmoid flexure, making early intervention in fast-growing calves critical (Tiruneh, 2000; Mejia *et al*., 2022).

This risk underlines the importance of early detection and preventive management in fast-growing or overweight calves, especially in intensive production systems where dietary mineral levels and water consumption are tightly regulated but not well-balanced.

Conduction of surgical treatment achieves high economic revenue in the short run and increases when counting on the long run, especially when the affected animal is young age. The results revealed that the revenue for the L.E. in all surgical operations is always positive and encourages performing such surgical interferences (Nassar, 1992).

Benefits/Cost ratio (L) reveals the limits to which economic efficiency could be achieved, when it equals one, it means equality of benefits and costs, without net revenue, and this wasn't recorded in all surgical interventions. On the other hand, when the ratio is less than one, it means that economic efficiency wasn't achieved as a result of these surgical interventions, and this also wasn't recorded in all affections of this study. When the ratio is higher than one, this means that economic efficiency is achieved by using such surgical treatments (Gitinger, 1973; Kleibohmer and Sobiraj, 2004).

The economic revenue of the surgical interventions not only affects the economic impact of the small owners and the big farms, but it also has an important role in the induction of social impact as it achieves social stability through the development of the livestock which is considered the first concern of the small scale owners and that in turn reflected on the national livestock production (Abdel-Fettah and Saleh, 2005).

Conclusion

The study provides valuable insights into epidemiology, clinical presentation, biochemical alterations, and surgical management of obstructive urolithiasis in calves. Younger and lighter calves are particularly susceptible to severe complications, highlighting the need for early detection and intervention. The findings underscore the importance of comprehensive clinical and biochemical evaluations in diagnosing and managing urinary tract obstructions. Surgical interventions, while effective, require careful postoperative management to minimize complications. The study also emphasizes the role of environmental and management practices in the prevention and control of urolithiasis in calves. The guidance and informing the owners of calves suffering from urine retention with the importance and necessity of surgical interferences for the solution of the surgical problem in calves to reduce the loss and maximize economic benefit.

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Conflict of interest

The authors have no conflict of interest to declare.

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