LITERATURE REVIEW: THE USE OF SUBCUTANEOUS URETERAL BYPASS IN THE TREATMENT OF UROLITHIASIS IN FELINES

Revisão de literatura: o uso de desvio ureteral subcutâneo no tratamento de urolitíase em felinos

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Abstract

Feline ureterolithiasis is a clinically significant condition commonly associated with ureteral obstruction and progression to chronic kidney disease (CKD). Due to the limitations of conventional surgical techniques, the subcutaneous ureteral bypass (SUB) has emerged as an effective therapeutic alternative, particularly in cases involving ureteral stenosis or when restoration of ureteral patency is not feasible. This study aims to review the current literature on the use of SUB, highlighting its indications, advantages, and associated complications. The technique demonstrates high efficacy in restoring urinary flow, leading to significant clinical improvement and increased patient survival. However, complications such as device obstruction, mineralization, and urinary tract infections have been reported, requiring strict postoperative monitoring. In conclusion, SUB represents a promising and less invasive surgical option compared to traditional methods, although further studies are needed to refine its indications and reduce long-term complication rates.

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Keywords: Cats. Ureterolithiasis. Ureteral obstruction. Subcutaneous ureteral by-pass.

Resumo

A ureterolitíase em felinos é uma condição de elevada relevância clínica, frequentemente associada à obstrução ureteral e à progressão da doença renal crônica (DRC). Diante das limitações das técnicas cirúrgicas convencionais, o desvio ureteral subcutâneo (SUB) tem emergido como alternativa terapêutica eficaz, sobretudo em casos de estenose ureteral ou impossibilidade de restabelecimento do fluxo urinário. Este estudo revisa a literatura acerca do uso do SUB, enfatizando suas indicações, benefícios e complicações associadas. A técnica apresenta alta taxa de sucesso na restauração do fluxo urinário, promovendo melhora clínica significativa e aumento da sobrevida dos pacientes. Entretanto, complicações como obstrução do dispositivo, mineralização e infecções do trato urinário são descritas, demandando monitoramento pós-operatório contínuo. Conclui-se que o SUB constitui uma abordagem promissora e menos invasiva, embora estudos adicionais sejam necessários para otimizar sua aplicação clínica.

Palavras-chave: Felinos. Ureterolitíase. Obstrução ureteral. Desvio ureteral subcutâneo.

Introduction

Ureterolithiasis is characterized by the formation of uroliths in the upper urinary tract, specifically within the ureters, resulting from the precipitation of minerals in the urine (Little, 2017). In most cases, these calculi are composed of calcium oxalate and struvite (Gomes *et al*., 2018). Ureteral obstructions can be classified as intraluminal, intramural, or extramural, with the intraluminal type being the most common (Shipov; Segev, 2013). This type of obstruction leads to increased intraluminal pressure, with subsequent release of vasoactive mediators, leukocyte influx, and renal fibrosis, ultimately reducing the glomerular filtration rate (Defarges; Berent; Dunn, 2013).

Ureteral calculi are considered the primary cause of ureteral obstruction in felines and have shown a significant increase in incidence, a trend that has persisted over recent decades (Geddes *et al*., 2023). Clinical signs are generally subtle and nonspecific, which hinders early diagnosis and compromises therapeutic prognosis (Jericó; Andrade Neto; Kogika, 2023; Cuddy, 2018). Prolonged obstructions result in progressive renal damage, including atrophy of the affected kidney and compensatory hypertrophy of the contralateral kidney (Shipov; Segev, 2013). Chronic kidney disease may arise as a consequence of acute kidney injury secondary to obstruction, which can be fatal if adequate renal decompression is not achieved (Hsu *et al*., 2022; Vrijsen *et al*., 2021).

Conventional surgical techniques, such as ureterotomy, neoureterocystostomy, and ureteronephrectomy, are associated with high morbidity and mortality rates, including complications such as uroabdomen and strictures that compromise the ureteral lumen (Vrijsen *et al*., 2021). In this context, less invasive methods have been developed to restore urinary flow, including the use of ureteral stents and subcutaneous ureteral bypass (SUB) systems (Horowitz *et al*., 2013). Among these, SUB stands out for offering shorter surgical time, lower complication rates, reduced need for reintervention, and increased patient survival (Deroy *et al*., 2017).

The choice between ureteral stents and SUB should be individualized, taking into account ureteral anatomical integrity, the etiology of the obstruction, and the patient's clinical condition. In general, stents are more suitable for simple intraluminal obstructions, where the ureter remains patent and there is no significant stenosis, whereas SUB is preferred in cases of ureteral stenosis,

complex or recurrent obstructions, non-catheterizable ureters, and previous stent failure (Berent *et al*., 2018; Deroy *et al*., 2017). In felines, however, the use of stents presents important practical limitations, primarily due to the small diameter of the ureteral lumen, making the procedure technically challenging (Kulendra *et al*., 2014). Additionally, it is associated with complications such as stranguria, pollakiuria, hematuria, and cystitis due to bladder irritation (Deroy *et al*., 2017), as well as long-term encrustation, which may lead to device obstruction (Deroy *et al*., 2017).

In specific clinical scenarios, such as the presence of chronic kidney disease (CKD), bilateral obstructions, or ureteral stenosis, SUB tends to be the preferred technique, as it provides more stable and long-lasting renal decompression, better preservation of renal function, and increased survival (Butty; Labato, 2021; Berent; Weisse, 2018). In this context, its impact on surgical decision-making is significant, as SUB is associated with shorter operative time, fewer reinterventions, and improved long-term outcomes compared to ureteral stents (Deroy *et al*., 2017). It is particularly indicated in patients with greater clinical severity or anesthetic limitations (Berent *et al*., 2018), whereas stents, although useful in selected cases, require greater technical expertise and are more prone to complications, limiting their applicability in routine feline clinical practice (Kulendra *et al*., 2014; Deroy *et al*., 2017).

Thus, this article aims to review the literature on ureterolithiasis in felines and to evaluate the role of SUB as a less invasive technique, highlighting its advantages and the main complications reported in the literature.

Methodology

This study consists of a narrative literature review based on scientific articles, reviews, and consensus statements published between 2010 and 2025. The search was conducted in the PubMed, SciELO, and Wiley Online Library databases using the descriptors *feline urolithiasis*, *ureteral obstruction in cats*, *subcutaneous ureteral bypass*, and *ureterolithiasis in cats*.

Studies addressing the etiology, pathophysiology, diagnosis, and treatment of ureterolithiasis in felines were included, with emphasis on minimally invasive surgical approaches, particularly SUB, as well as comparisons with ureteral stents. Review articles, retrospective studies, and international consensus statements published in Portuguese and English were considered.

Duplicate studies, studies focusing on other species, publications addressing exclusively conventional surgical techniques, and studies not directly related to ureteral obstruction in felines were excluded.

The selected studies were critically analyzed regarding clinical relevance, applicability of findings, and level of evidence, prioritizing more recent publications with greater impact on clinical practice. Approximately 25 studies were ultimately deemed eligible and were organized according to the evolution of knowledge on the topic.

Review and Discussion

Understanding renal anatomy and physiology is essential for elucidating the mechanisms involved in feline urolithiasis and the complications associated with ureteral obstructions. The urinary system consists of two kidneys, two ureters, the urinary bladder, and the urethra—structures responsible for blood filtration, urine formation, transport, storage, and excretion (König; Liebich, 2021; Dyce; Sack; Wensig, 2019). The right kidney

is positioned more cranially than the left, and both are located in the retroperitoneal space, lateral to the aorta and caudal vena cava, surrounded by a fibrous capsule (Fossum *et al*., 2021). Renal vascularization originates from the renal artery, a direct branch of the abdominal aorta, which divides into dorsal and ventral branches and may present anatomical variations (König; Liebich, 2021). Urine formed in the renal pelvis is transported through the ureters, muscular tubes that run along the dorsal wall of the abdominal cavity and enter the bladder obliquely (König; Liebich, 2021).

From a physiological perspective, the nephron represents the functional unit of the kidney, composed of the glomerulus, Bowman's capsule, and renal tubules. Urine formation involves three fundamental processes: glomerular filtration, tubular reabsorption, and tubular secretion, all regulated by glomerular pressure and osmotic gradients (Reece *et al*., 2019). Alterations in these mechanisms may lead to imbalances in urinary solute concentration, resulting in supersaturation and subsequent crystal formation, which constitutes the initial event in urolithiasis (Little, 2017).

Urolithiasis is a globally distributed condition characterized by the presence of uroliths throughout the urinary tract. Ureteral obstruction caused by calculi or other factors leads to acute kidney injury in cats, with incidence increasing significantly between 1984 and 2002 (Etedali; Reetz; Foster, 2019). The main causes of ureteral obstruction include calculi, stenosis, circumcaval ureters, neoplasia, mucus plugs, blood clots, fibrosis, and surgical trauma (Gomes *et al*., 2022). Ureterolithiasis is the leading cause of ureteral obstruction in felines, accounting for approximately 82% of cases and is typically associated with calcium oxalate uroliths (Geddes *et al*., 2023).

The literature indicates a predominance of specific breeds, such as Ragdoll, Tonkinese, Persian, British Shorthair, and Birman, with a higher incidence in middle-aged to older animals. This suggests that genetic factors, combined with metabolic and dietary predispositions, play a central role in the occurrence of ureterolithiasis (Geddes *et al*., 2023; Jericó; Andrade Neto; Kogika, 2023). These epidemiological data support the hypothesis that the interaction between genetic and environmental determinants—including diet composition and water intake habits—contributes to urinary supersaturation and urolith formation, predominantly composed of calcium oxalate and struvite (Little, 2017; Etedali; Reetz; Foster, 2019; Gomes *et al*., 2018).

The ureteral obstructive process, often intraluminal, compromises renal hemodynamics by increasing intraluminal and pelvic pressure, directly affecting the renal tubules and Bowman's space, thereby reducing the glomerular filtration rate (Shipov; Segev, 2013). This pathophysiological phenomenon is further amplified by the activation of vasoactive mediators and leukocyte recruitment, culminating in progressive renal fibrosis (Defarges; Berent; Dunn, 2013). The progression of obstruction not only impairs the affected kidney through fibrosis but also imposes an increased functional burden on the contralateral kidney as a compensatory mechanism, predisposing to chronic kidney disease, particularly in subclinical conditions in which renal function is compromised prior to the onset of evident clinical signs (Hsu *et al*., 2022; Santos; Alessi, 2022).

The clinical presentation of ureterolithiasis is often nonspecific, typically characterized by anorexia, weight loss, and vomiting, which complicates early diagnosis and reduces therapeutic effectiveness (Jericó; Andrade Neto; Kogika, 2023; Cuddy, 2018). In cases of chronic unilateral obstruction followed by acute contralateral obstruction, felines may present with uremia, acute abdominal pain, and distension of the renal capsule, conditions that require urgent intervention to prevent renal necrosis and progression to anuria (Jericó; Andrade Neto; Kogika, 2023).

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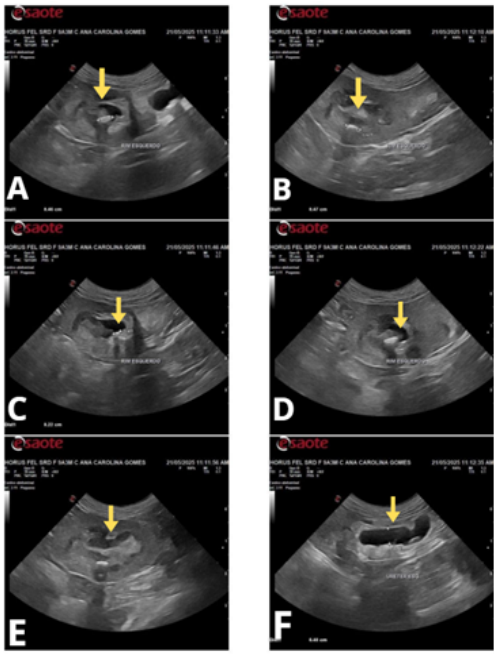
Diagnosis should integrate clinical, laboratory, and imaging findings. A detailed clinical history—including information on diet, home environment, and prior medical history, often marked by nonspecific manifestations—must be correlated with complementary diagnostic results. Particular attention should be given to biochemical alterations such as hyperkalemia, hyperphosphatemia, hypercalcemia, and azotemia, as well as changes in urinary density and pH, which are critical for diagnostic clarification (Gomes *et al*., 2022; Little, 2017; Jericó; Andrade Neto; Kogika, 2023).

As clinical signs are not always evident, upper urinary tract urolithiasis may contribute subclinically to cases of chronic kidney disease of unknown origin. The high prevalence of this condition suggests that it may itself be a causative factor for CKD, as obstruction by nephroliths or ureteroliths can result in significant renal injury, particularly in unilateral cases and in the absence of pre-existing renal disease (Hsu *et al*., 2022).

Imaging studies are essential for the diagnosis and monitoring of urolithiasis in felines. Abdominal radiography and ultrasonography are key tools for the localization and characterization of uroliths, allowing assessment of their number, shape, contour, density, and anatomical position, as well as the identification of secondary changes such as hydronephrosis and hydroureter, and monitoring of the affected kidney (Jericó; Andrade Neto; Kogika, 2023). Although radiography enables the detection of calculi, ultrasonography is considered the modality of choice, as it allows evaluation of pyelectasia and ureteral dilation associated with obstructive lesions (Cuddy, 2018). In inconclusive cases or when conventional imaging methods are insufficient, percutaneous antegrade pyelography—preferably ultrasound-guided—remains indicated as a complementary method, enabling detailed visualization of the renal pelvis and ureter and contributing to diagnostic confirmation (Etedali; Reetz; Foster, 2019; Lulich *et al*., 2016).

Figure 1 – Renal ultrasonography in a feline with ureterolithiasis and hydroureter



Source: Author's personal archive (Cardoso, 2025).

Caption: Ultrasonographic image of the left kidney of a feline showing dilation of the renal pelvis (pyelectasia) associated with the presence of a hyperechoic structure consistent with a urolith in the renal pelvis, as well as proximal ureteral dilation (hydroureter), consistent with ureteral obstruction. (A–D) renal sections demonstrating pyelectasia; (E–F) identification of a dilated ureter with hyperechoic content.

The identification of hydronephrosis and proximal hydroureter via ultrasonography is, in most cases, sufficient for the diagnosis of ureteral obstruction. Dilation of the renal pelvis represents one of the earliest detectable changes, with values exceeding 12.5 mm being highly suggestive of obstruction. However, this finding is not specific and may also be associated with conditions such as pyelonephritis, increased diuresis due to non-renal causes, or renal insufficiency (Etedali; Reetz; Foster, 2019). Conversely, when renal pelvic dilation is less than 5 mm, more detailed imaging techniques are required for diagnostic confirmation, except in cases where concurrent proximal hydroureter is present alongside a ureterolith, in which case the diagnosis can be established with greater confidence (Lulich *et al*., 2016).

Ureteral obstructions can be potentially fatal in felines, primarily due to the development of secondary acute kidney injury. In such cases, early treatment should prioritize renal decompression and preservation of renal function (Vrijsen *et al*., 2021). A conservative approach involving monitoring of asymptomatic felines with uroliths is not applicable when these are located in the upper urinary tract (kidneys and ureters), as delaying appropriate treatment may result in irreversible loss of renal function. Ureteral obstructions should only be monitored when renal pelvic dilation is ≤ 3–5 mm and renal function remains stable (Lulich *et al*., 2016).

The American College of Veterinary Internal Medicine (ACVIM) consensus emphasizes that clinical management of ureterolithiasis is rarely effective and may be considered only for a period of 24 to 72 hours. During this interval, diuresis with fluids is recommended, when feasible, in combination with continuous infusion of mannitol at a dose of 500 mg to 1 g/kg, as well as the use of alpha-adrenergic antagonists and tricyclic antidepressants. Patients who develop persistent oliguria or anuria, hyperkalemia, azotemia, and progressive dilation of the renal pelvis should undergo minimally invasive urolith extraction (Lulich *et al*., 2016).

Conventional surgical techniques, such as ureterotomy and neoureterocystostomy, although effective in the short term, are associated with high morbidity and mortality rates, including complications such as ureteral strictures, recurrence of obstruction, and uroabdomen, often requiring reintervention (Vrijsen *et al*., 2021; Horowitz *et al*., 2013). This scenario has driven the development of minimally invasive techniques aimed at restoring urinary flow, including the use of ureteral stents and the SUB.

Comparative analysis between ureteral stents and SUB highlights important differences regarding clinical applicability, technical limitations, and long-term outcomes in felines with ureteral obstruction. Ureteral stents, although effective in promoting passive ureteral dilation and restoring urinary flow in intraluminal obstructions, present significant limitations in felines, mainly due to the small diameter of the ureteral lumen. This makes implantation technically challenging and associated with a higher risk of complications (Kulendra *et al*., 2014). Additionally, lower urinary tract signs such as stranguria, pollakiuria, hematuria, and cystitis are frequently observed postoperatively, negatively impacting patients' quality of life, compromising urinary function, and requiring continuous monitoring. In the long term, encrustation and device obstruction represent significant complications, particularly in patients with chronic kidney disease or concurrent urinary tract infection (Deroy *et al*., 2017; Horowitz *et al*., 2013; Vrijsen *et al*., 2021).

The SUB has become the preferred option for renal decompression in cases of benign ureteral obstruction in felines, demonstrating a favorable prognosis and lower morbidity and mortality rates compared to traditional surgical techniques (Covo; Berent; Weisse, 2024). Its effectiveness is also noteworthy in felines previously diagnosed with

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chronic kidney disease, in which the procedure contributes to preserving renal function and improving survival (Butty; Labato, 2021). Berent *et al*. (2018) further support the use of the SUB device as an alternative in cases where stent placement (Figure 2) is contraindicated and in situations where the patient cannot tolerate prolonged anesthesia.

Figure 2 – Removed and damaged ureteral stents

Source: Author's personal archive (Cardoso, 2025).
Caption: Ureteral stents following surgical removal, showing mineral encrustations and structural deformities associated with their curvature.

Despite these advantages, some studies highlight that the method is not free of complications, which are often related to postoperative management and the experience of the surgical team. From this perspective, the choice between techniques should be based on an individualized assessment of the patient, considering ureteral anatomy, the etiology of the obstruction, clinical status, and technical availability. In more complex scenarios, SUB is frequently regarded as the technique of choice (Berent; Weisse, 2018; Vrijsen *et al*., 2021).

The SUB is an extra-anatomical device designed to restore urinary flow, primarily indicated in cases of ureteral obstruction. The system consists of a nephrostomy catheter inserted into the caudal pole of the kidney, extending to the renal pelvis (Figures 3 and 4), with fluoroscopy optionally used as an adjunct during the procedure. Following insertion, the Dacron cuff is secured to the renal capsule using cyanoacrylate tissue adhesive, ensuring stabilization of the nephrostomy catheter. The system also includes a cystotomy catheter; both catheters are exteriorized through the abdominal wall and connected to a subcutaneous port, establishing a permanent alternative pathway for urinary drainage. By enabling immediate renal decompression, the device contributes to the preservation of renal function and demonstrates lower morbidity compared to conventional ureteral techniques (Berent; Weisse, 2018).

Figure 3 – Ultrasonography of the renal pelvis with nephrostomy catheter in place

Source: Author's personal archive (Cardoso, 2025).

Caption: Renal ultrasonography emphasizing the renal pelvis, where the yellow arrow indicates the curvature of the appropriately positioned nephrostomy catheter tip.

Figure 4 – Nephrostomy catheter and Dacron cuff inserted at the caudal pole of the kidney

Source: Author's personal archive (Cardoso, 2025).

Caption: Image showing fixation of the Dacron cuff to the renal capsule at the caudal pole, representing the final step for proper stabilization of the nephrostomy catheter.

Following device placement, it is recommended to flush the system with a mixture of 50% iodinated contrast and 50% sterile saline under fluoroscopic guidance, allowing monitoring of filling of both the renal pelvis and the urinary bladder. After completion of the procedure, radiographic evaluation (Figure 5) should be performed in ventrodorsal and laterolateral projections to rule out kinking, excessive angulation, or improper catheter positioning (Berent; Weisse, 2018).

Figure 5 – Postoperative abdominal radiograph with SUB device in place

Source: Author's personal archive (Cardoso, 2025).
Caption: Ventrodorsal abdominal radiograph in the postoperative period confirming correct positioning of the nephrostomy and cystotomy catheters, as well as proper fixation of the subcutaneous port.

Studies indicate that the SUB is associated with lower morbidity and mortality rates, reduced surgical time, fewer intra- and postoperative complications, decreased need for reintervention, and prolonged survival in felines with ureterolithiasis or concurrent chronic kidney disease (Deroy *et al*., 2017; Covo; Berent; Weisse, 2024; Butty; Labato, 2021). Postoperative complications, including leakage, kinking, device occlusion, dysuria, and urinary tract infections, can be minimized through regular system flushing and the use of 2% ethylenediaminetetraacetic acid (EDTA) (Figure 6), which helps prevent biofilm formation and mineral deposition (Berent; Weisse, 2018).

Figure 6 – 2% EDTA vial and subcutaneous port access system

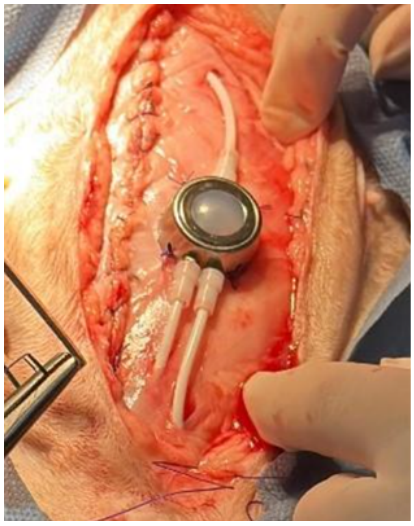
Source: Author's personal archive (Cardoso, 2025).
Caption: Subcutaneous port assembly with infusion set and 2% EDTA vial, demonstrating the system used for access, infusion, and maintenance of implantable urinary devices.

Short-term complications include obstruction of one of the catheters by blood clots, system blockage by calculi, seroma formation, and, occasionally, urethral obstruction caused by the passage of uroliths. Long-term complications include obstruction due to mineralization, catheter kinking, and the formation of blood clots (Berent *et al*., 2018).

Postoperative urinary tract infection is a frequent complication, mainly attributed to biofilm formation and urinary stasis. For this reason, regular clinical follow-up is recommended, along with further investigation in persistent cases. Additional studies are still needed to establish the optimal antimicrobial protocol to be used during and after SUB placement (Vrijsen *et al*., 2021).

An improved version of the SUB, featuring fully intra-abdominal catheters connected to a subcutaneous port (Figure 7), has demonstrated a significant reduction in infection and mineralization rates after one year of follow-up, reinforcing the continuous advancement of the technique (Berent; Weisse, 2020).

Figure 7 – Implantation and fixation of the subcutaneous port in a subcutaneous ureteral bypass system



Source: Author's personal archive (Cardoso, 2025).
Caption: Positioning and fixation of the SUB system's subcutaneous port, connected to the nephrostomy and cystostomy catheters within the subcutaneous plane.

Complication rates are likely to vary across different centers, highlighting the importance of establishing a centralized database of patients undergoing SUB procedures. Proper use of such a resource would enable the identification of specific issues, assisting surgeons in understanding complication rates across institutions and in implementing more robust clinical audits (Kulendra *et al*., 2014).

The literature indicates that early intervention, combined with continuous clinical monitoring, is critical for reducing complications and optimizing clinical outcomes in felines with ureteral obstruction. In this context, therapeutic success depends on the integration of accurate diagnosis, appropriate technique selection, and rigorous clinical management (Horowitz *et al*., 2013; Lulich *et al*., 2016; Butty; Labato, 2021).

Conclusion

In summary, the reviewed literature demonstrates that ureteral obstruction in felines is a condition of increasing clinical relevance, requiring early diagnosis and appropriate intervention to preserve renal function. Minimally invasive techniques, particularly the SUB, have shown greater safety and long-term efficacy, with lower morbidity and mortality rates

compared to traditional methods such as surgical extraction and ureteral stents. Despite these advances, gaps remain, including the scarcity of long-term comparative studies and variability in clinical protocols. Therefore, the choice of technique should be guided by its capacity to relieve obstruction, ensure procedural safety, preserve renal function, and optimize survival outcomes in feline patients. &

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