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Urogenital and Perineal Surgery for Advanced Practitioners Mini Series

Session One: Surgical Treatment of Obstructive Disease Part 1

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Urinary and Reproductive tract surgery

Surgical anatomy of the urinary system

Kidneys

The kidneys are paired bean shaped structures located in the retroperitoneal space ventral to the sublumbar muscles. The right kidney is located more cranially than the left. The cranial pole is in contact with renal fossa of the caudate liver lobe. The cranial pole of the left kidney lies lateral to the left adrenal gland, which is associated with the left renal vessels. The left kidney tends to be more mobile than the right. The kidneys are surrounded by lumbar fat and in some obese animals they can be covered by fat.

A capsule surrounds the kidney, in a healthy animal this capsule can separate easily from the kidney, while in a disease animal the capsule can be thickened and tightly adhered to the renal tissue.

The renal vein is located more ventrally and the renal artery more dorsal. The renal arteries originate directly from the aorta. In most cases there will be only one renal artery but multiple arteries can be seen in 13% of dogs and 10% of cats. The left kidney is most likely to have more than one artery. Some arteries can branch after leaving the aorta. This can be important when performing a nephrectomy as if we don't ligate the multiple arteries hemorrhage will occur. When the artery reaches the kidney it divides into dorsal and ventral branches. Also small capsular arteries can enter the kidney from the capsular surface. These arteries can give some arterial flow if the renal artery is obstructed. These vessels normally originate from the phrenicoabdominal artery and adrenal arteries.

The renal vein finishes in the caudal vena cava. The left renal vein also receives blood from the left ovarian or testicular veins.

Ureters

The ureters are paired fibromuscular tubes that transport urine from the renal pelvis to the urinary bladder via peristaltic movement.

The luminal diameter of a non obstructed feline ureter is approximately 0.4mm. in the dogs the diameter will vary depending on dog size and breed. In dogs of 21 to 39 kg its around 2-2.5mm.

The ureters after leaving the renal hilus will course ventral to the psoas muscles in the retroperitoneal space. The right ureter lies lateral to the vena cava and may pass dorsal to the vena cava returning to its normal place. After passing ventral to the external iliac vessels the ureters turn ventrally toward the trigone of the urinary bladder. In males they will course dorsal to the ductus deferens before entering the bladder wall. They have a "J" shape as they enter the bladder. Then run obliquely within the wall for a short distance toward the trigone finishing in a slit like or horseshoe shaped orifice cranial to the internal urethral sphincter.

The blood supply of the ureter, the ureteral artery arises from the caudal aspect of the renal artery and anastomoses with the ureteric branch of the caudal vesicular artery, which originates from the prostatic or vaginal artery.

Bladder

The bladder lies in the peritoneal cavity and is attached loosely to the abdominal wall by a double layer of peritoneal ligaments. The ventral median ligament which connects the bladder to the linea alba and pelvic symphysis; can be cut when we perform a cystotomy. The lateral ligaments attach the bladder to the pelvic walls, this can also be cut but be careful as the final part of the ureters run through this ligament.

The position of the bladder wild depend on the volume of its content. Lies cranial or within the pelvic canal when empty. The fully distended bladder of a normal dog may be partially located within the pelvic canal. In cats the bladder will be in the abdomen even when empty.

Innervation

Except during micturition the smooth muscle at the vesicourethral junction is maintained in a steady state of contraction by sympathetic stimulation of α adrenergic receptors in the bladder neck and proximal urethra via the hypogastric nerve. Sympathetic hypogastric nerve stimulation of β adrenergic receptors in the bladder wall relax the detrusor muscle, allowing storage of the urine.

When the bladder is full it stretches receptors in the detrusor muscle, resulting in parasympathetic pelvic nerve stimulation initiates reflex detrusor muscle contraction and urination. The stretch receptors in the bladder wall will also depress sympathetic outflow and cause relaxation of the smooth and striated urethral muscles, permitting urination. The parasympathetic pelvic nerves originate in the sacral spinal cord (S1-S3).

The pudendal nerve originates in the sacral spinal cord and provides somatic innervation to the periurethral striated muscle at the bladder neck (external urethral sphincter). The external urethral striated muscle, similar to the smooth muscle in this region remains in a state of steady contraction, contributing to active urethral resistance during the urine storage and is inhibited during reflex urination. Additionally voluntary control can initiate or inhibit the detrusor reflex so that micturition occurs at an appropriate time. Voluntary control occurs via the somatic pudendal nerve innervation of striated urethral musculature and direct cortical innervation of the pontine micturition center.

All the innervation to the bladder merges together at the pelvic plexus before entering along the dorsal surface in the region of the bladder neck.

The vascular supply also enters dorsally. The caudal vesical artery in the major arterial supply. It arises from the uterine or prostatic branch of the internal pudendal artery. The cranial vesical artery in the terminal ending of the umbilical artery, but it may not be patent in the adult dog. Lymphatics drain into the hypogastric and sublumbar lymph nodes.

Urethra

Male dog: it's relatively long around 10-35 cm and varies widely in length and diameter proximal to the os penis to permit urination and ejaculation. Its divided in three segments, preprostatic, prostatic and cavernous urethra. The first two are located in the pelvic canal, the cavernous starts at the ischial arch.

Male cats: cats have a distinct preprostatic urethra that contributes to a long internal urethral sphincter.

Female dogs: is shorter and wider than in males

Female cats: the relatively length is comparable to that of female dogs.

Obstructive disease of the urinary tract, ureters, bladder and urethra

Renal Calculi

Renal calculi form because of oversaturation of urine with calculogenic substances. Plasma concentration of calculogenic substances may increase by a variety of causes such as:

- organ dysfunction (hyperammonemia due to secondary liver disease)
- neoplasia (hypercalcemia secondary to primary hyperparathyroidism or paraneoplastic syndrome)
- increased calcium intake, drugs, increased intestinal absorption, impaired renal reabsorption, and skeletal mobilization.

The incidence of nephroliths in dogs and cats has increased and is the primary reason to perform renal surgery. most feline calculi are composed of calcium salts (calcium oxalate or calcium phosphate).

Clinical signs of nephrolithiasis may be absent or nonspecific(vomiting, lethargy, anorexia) or may be associated to the underlying disorder.

Other clinical signs may include renomegaly, haematuria, pyelonephritis, primary renal failure, abdominal pain.

Changes in blood work are usually mild or absent unless obstruction, pyelonephritis or if there is an underlying condition.

Abnormalities on urinalysis may include hematuria, pyuria, bacteriuria or crystalluria. Urine culture is normally negative.

Diagnostic imaging especially radiographs can be useful as most renal calculi are radiopaque, however ultrasound will detect all calculi independent of their composition. The whole urinary tract should be imaged.

Treatment
The most common renal calculi are composed of calcium oxalate and cannot be dissolved medically.
Surgery should be considered if:

- nephroliths are causing obstruction that affects renal function
- associated with severe hematuria
- persistent urinary infections
- pain
- increasing in size and damaging renal tissue

Treatment options include:

- lithotripsy
- nephrotomy
- pyelolithotomy
- nephrectomy should only be considered when there is severe hydronephrosis, infected or non functional kidney

We have to keep in mind that the presence of nephroliths is not necessarily an indication for intervention.

Nephrotomy:

Indications:

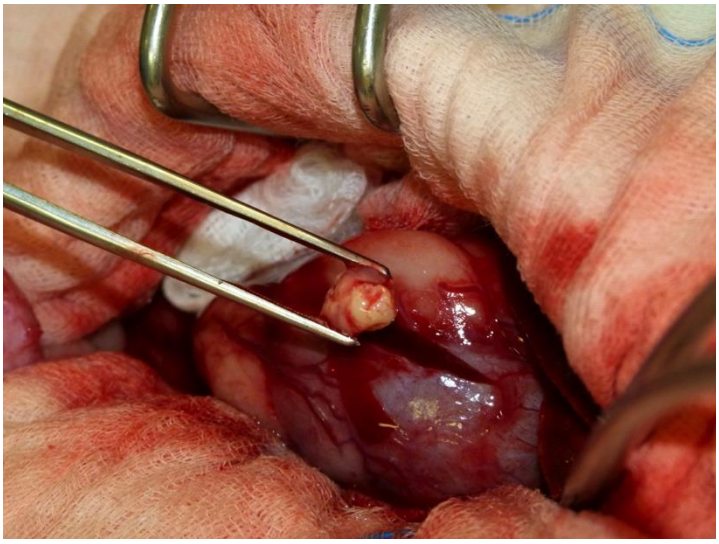
- To obtain tissue samples
- Gain access to the renal pelvis for removal of nephroliths or other obstructive lesions.

Renoliths are removed when they are associated with partial or complete obstruction and subsequent pelvic dilation, when they are thought to be a nidus for infection or when there is progressive enlargement and deterioration of renal function.

Surgical technique

1. Release the kidney from its retroperitoneal attachments: this will provide better access for temporary occlusion of the renal vessels.
2. A vascular clamp (Satinsky) can be passed dorsal to the kidney and closed just enough to occlude renal blood flow. Hemostats should not be used as it can damage the endothelium and provoke thrombosis
3. Kidney is incised on the midline through the renal capsule, incision is made as big as needed, if it s a small calculi a small incision is needed but if there is a large or multiple calculi a larger incision may be needed

4. Renal parenchyma is then sharply incised or can also be done bluntly, supposedly the blunt dissection will cause less hemorrhage. But there is no difference of damage of renal function between the two techniques
5. Calculi are removed and flushed to remove all debris
6. If a renal biopsy is needed this can be obtained at this time
7. Closure can be achieved through a variety of techniques
    a. Direct compression for 1-5 minutes, this will form a fibrin seal, followed by a simple continuous suture just involving the renal capsule
    b. Suturing: horizontal mattress sutures placed through the capsule and partial thickness into the renal cortex. Excessively large, deep or too tight sutures can cause more renal damage than the nephrotomy in itself. A simple continuous suture can also be used
8. Kidney is placed into the retroperitoneal fossa, careful not to twist the pedicle.
9. Nephropexy. Several mattress sutures are placed through the renal capsule to the adjacent body wall.



Effect of nephrotomy on renal function

Further reduction of renal function from surgical intervention could result in patient deterioration. There have been many studies with inconsistent results, most of this studies were performed in healthy dogs and cats, in this patients probably a bisectional nephrotomy will not affect glomerular filtration rate. This findings may not be applicable to patients with pre-existing renal disease.

Ureteral calculi

The series of physiologic events that occurs after ureteral obstruction is complex, and after relief of the obstruction changes continue to occur in the previously obstructed kidney. After unilateral obstruction, ureteral pressures increase and peak by 5 hours and then lessen but remain increased 12 to 24hr after obstruction. After a transient increase, renal blood flow diminishes to 40% of normal over the first 24hr and continues to decrease to 20% after 2 weeks. The increase in pressure, which is transmitted to the renal tubules and glomeruli and decrease in blood flow are accompanied by a decrease in glomerular filtration rate through a complex interaction of a variety of vasoactive mediators.

The longer the duration of ureteral obstruction, the less likely that the kidney will recover to where the animal is no longer azotemic. In normal dogs after 1 week of obstruction glomerular filtration rate returns to 65% of control values after removing the obstruction. After two weeks glomerular filtration rate returns to only 46% of normal over 4 months. This was in healthy dogs.

Feline ureterolithiasis

Is probably the most common reason to perform ureteric surgery in cats. Once identified its important to stabilize the patient before any surgery
Medical management: diuresis and the use of ureteral smooth muscle relaxant can be attempted for 1 to 4 days before surgery, to try and move the calculi to the bladder. This would eliminate the need of an ureterotomy, which is more difficult than a cystotomy.

Drugs that have been shown to induce ureteral relaxation in other species have not been widely investigated in cats and dogs: calcium channel blockers, glucagon, amitriptyline. Amitriptyline may have some beneficial effect in cats used at a dose of 10 mg/cat PO while on fluids. In a study of 4 cats the 4 passed the stones in seven days.

When treating medically its important to have into consideration the risks of increasing renal damage. It's also important to have into consideration if there is a total or partial obstruction.

Lithiotripsy: is not widely used in cats due to the risk of renal damage

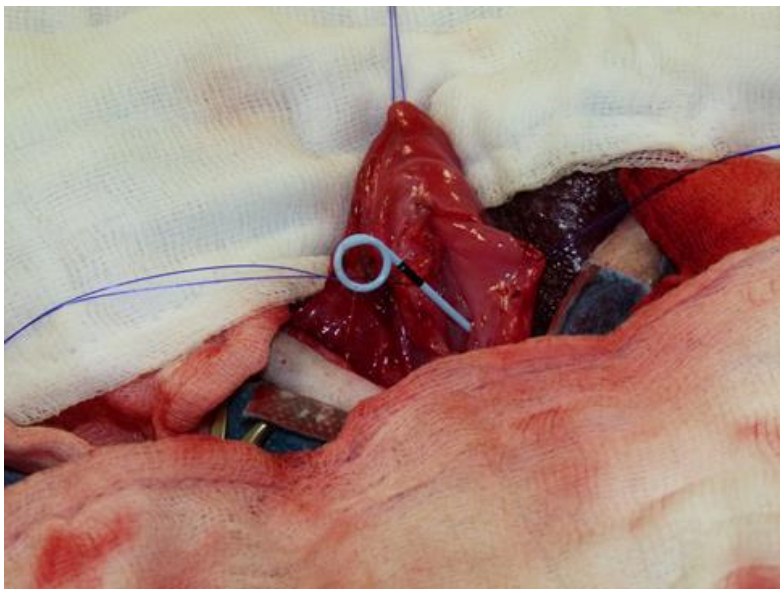
Surgical treatment:

Its important to note that most of this cats will have prior renal disease that probably is exacerbated by the ureterolith, most cats wont have a return to normal renal values.

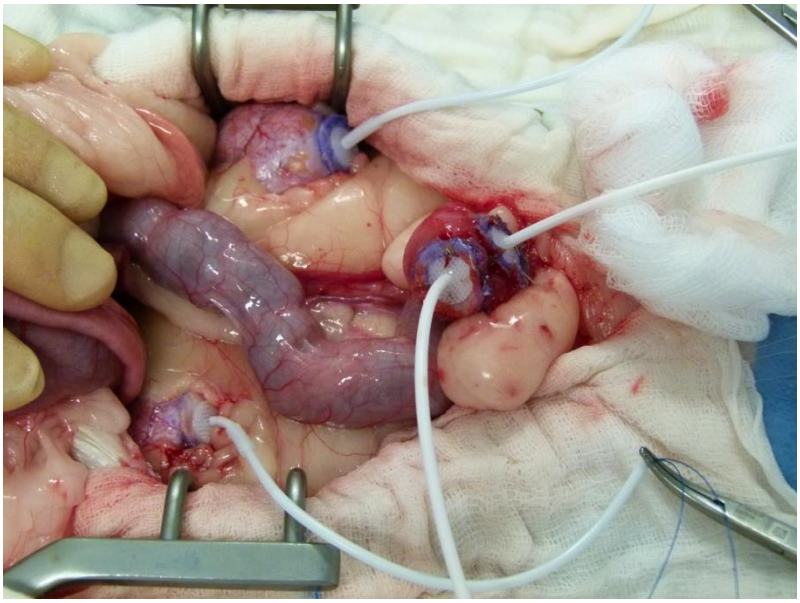
Localization of the urolith: this is most common performed with ultrasound but most of this cases the uroliths are made up of calcium oxalate and this can be seen on radiographs.. the added benefit of ultrasound is that it helps us determine the ureteric and renal pelvis dilatation. If there is distension but no obvious calculi then the cause could be a stricture, blood clot, or neoplasia

Surgery options:

- Ureterotomy, now a days this is rarely performed. The most common complication was urinary leakage or stricture. In a paper one third of cats had complications and 18% died.
- Ureteric resection/ reimplantation
- Ureteric stent



- Subcutaneous ureteric bypass: this technique is the preferred technique at this time.



Postoperative care:

- Analgesia
- Nutrition: If the animals are not eating its important to place a feeding tube.
- Fluidtherapy, crystalloids are used and slowly decreased as the biochemistry panels improve.
- Renal panel checked at least once a day

Canine ureterolithiasis

It's much less common in dogs. Half of dogs will also have calculi in kidney and bladder. The most common composition was struvite or calcium oxalate. Struvite stones are associated with increased white blood cells. Most of this dogs their renal values are wnl but there was hydroureter and hydronephrosis on imaging. The typical clinical signs are lethargy, vomiting and anorexia.

Treatment:

- Lithiotripsy: extracorporeal shockwave lithiotripsy can be used in dogs with good results.
- Ureterotomy
- Neoureterocystostomy
- Ureteral stents
- Subcutaneous ureteric bypass

Bladder Calculi

Bladder is the most common place but urolithiasis can involve one or more sites in the urinary tract. The vast majority of calculi in dogs and cats are either struvite or calcium oxalate. Less commonly identified are urate, calcium phosphate, silica, xanthine, cysteine and compound uroliths. In casts mineralized blood clots has also been described.

Clinical signs include hematuria, pollakuria, stranguria and dysuria, but this are also common to other lower urinary diseases. If there was urethral obstruction, then we could see progressive depression, vomiting and signs related to post renal azotemia. A large bladder or even a large calculi could be palpated. But normally physical examination ins not sensitive to identify calculi, sometimes with rectal palpation we may palate stones in the urethra.

Hematology and biochemistry may be normal except if there is urethral obstruction. Hypercalcemia is a risk factor for calcium oxalate stones. In 35% of cats with idiopathic hypercalcemia urolithiasis was observed. Patients with shunts can also developed urate stones.

Urine analysis may support a prediction for urolith type. Urine culture is always indicated as urinary infections was documented in 76% of dogs with stones.

Plain abdominal radiographs should identify calcium oxalate and struvite stones if larger than 1mm in size. Around 25% of plain radiographs may produce false negative for urate, cysteine and calcium phosphate uroliths of all sizes. Urethral calculi are more easily missed on radiographs. Pneumocystogram, double contrast cystography and ultrasound are the most sensitive techniques for detection of calculi. Accurate calculi count are obtained approximately 50% of the times with any of this techniques. If calculi are identified in the bladder its important that we image the whole urinary tract as there is the possibility of finding uroliths in other parts.

Medical therapy for the dissolution of struvite, urate and cysteine cystoliths and recommendation for the prevention of all types of calculi are well documented . calcium oxalate and silicate cystoliths require removal as they are not dissolvable.

Methods for retrieval of calculi from the bladder include:

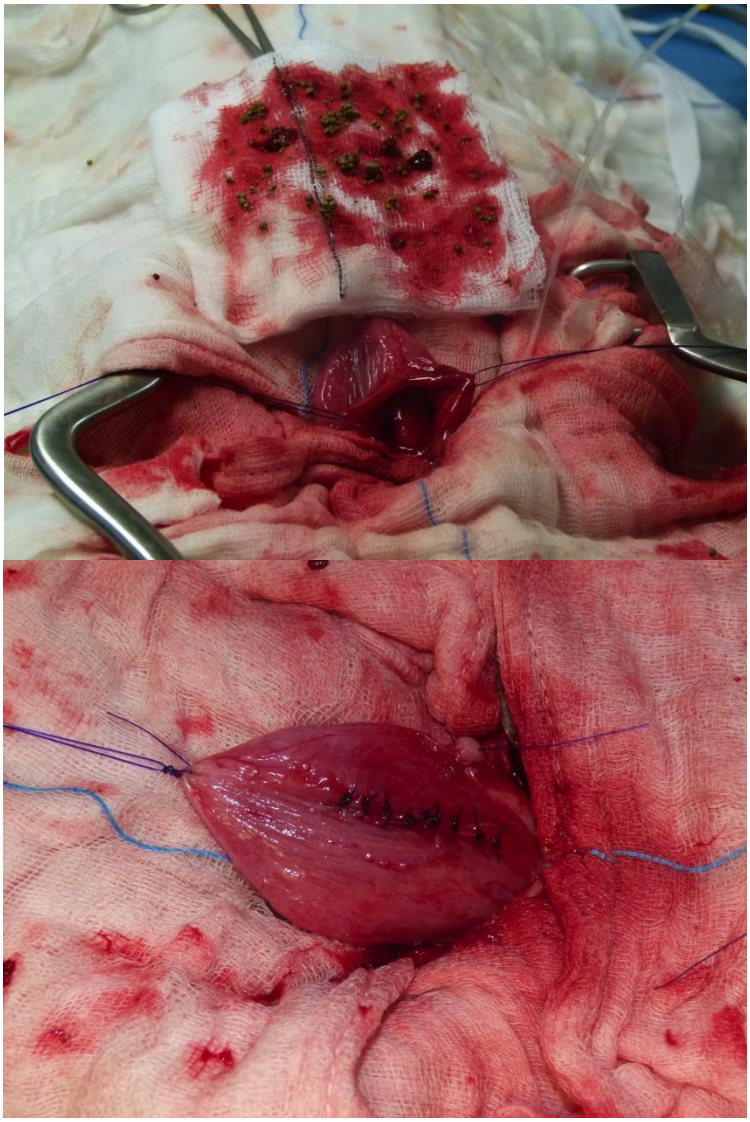
- Catheter assisted retrieval
- Transurethral cystoscopic retrieval
- Voiding hydropropulsion
- Laparoscope assisted cystotomy
- Surgical cystotomy
- Lithotripsy

Catheter assisted retrieval is done with an urinary catheter and is only used for very small stones
Voiding hydropulsion should be done with smooth uroliths smaller than the diameter of the urethra.
Lithiotripsy is the crushing or fragmenting of uroliths using shockwaves or laser energy. Now a days is more common to use laser lithiotripsy, like a Ho:YAG laser through the operating channel of the cystoscope

Surgical cystotomy:
Is the most common method for retrieving stones. Especially if there is urinary tract obstruction or if other methods of calculi removal or medical therapy are not appropriate, unavailable or have not been a success. To achieve success its important try to have an idea of how many stones were dealing with, its good to have performed some kind of imaging that would permit us to count the stones, normally plain or contrast radiographs. During the procedure is also important to visualize or palpate the entire mucosal lining to ensure no calculi is missed. A sterile scope can also be used for this purpose. Cystic calculi will fall into the proximal urethra when an animal is positioned for laparotomy, so it is essential to repeatedly flush the urethra in a retrograde manner while suction the bladder neck to ensure removal of all stones. Following surgery repeat radiographs is good practice to make sure we have not left any calculi behind. One retrospective study radiographically demonstrated residual calculi in 14% of dogs and 20% of cats.

- The approach to the bladder is made through a midline celiotomy extending from the umbilicus to the pubis, curving parapreputially through the skin and subcutaneous tissue in the male dog.
- The bladder is identified and isolated from the rest of the abdominal cavity with laparotomy swabs.
- A stay suture is placed in the apex.
- A dorsal or ventral approach can be made, there is no difference but a ventral approach is easier to perform, provides good visualization of the ureteral opening and reduces the risk of damage to this.

- A stab incision is performed with a scalpel blade in midline in an area with no large vessels.
- The incision is increased as needed with scissors
- Stay sutures are placed on the edges to improve visualization and decrease damage
- The bladder wall is closed with a monofilament absorbable suture, with a simple continuous, or simple interrupted, can be performed with a one layer or two layer closure.



Urolithiasis is likely to recur unless an underlying cause has been identified and addressed. Increased water intake, elimination of obesity and appropriate dietary or medical therapy for prevention are recommended to minimize the risk of recurrence. Struvite have been reported to recur in 21% of dogs. Urinary tract infection associated struvite can be eradicated by preventing or controlling urinary tract infection. In cats a diet that reduces urine pH is usually effective in preventing the recurrence of sterile struvite uroliths. Up to 50% of calcium oxalate uroliths recur within 3 years in dogs. A non acidifying high moisture not containing excessive protein is indicated. Urate calculi can recur in 33% of dogs. If the cause was not due to liver disease preventive therapy is feeding a high moisture protein restricted alkalinizing diet. Allopurinol in not longer recommended due to the production of xanthine stones. Cysteine calculi reoccurs in 47% of dogs. Dietary changes are made first and if necessary then 2,3 MPG has prevented reoccurrence in 86% of dogs. The recurrence of silicate has been reported in 12%.