# OBSTRUCTIVE UROPATHIES

Sarah Gradilla, DVM

ECC Resident, CUVS

# OUTLINE

- Urethral obstruction
- Obstructive urolithiasis
- Urinary diversion in the ER
- Reflex dyssynergia
- Feline UO
- Urethral trauma
- Ureteral obstruction
- Urinary neoplasia

# URETHRAL OBSTRUCTION

# URETHRAL OBSTRUCTION

Etiology/Pathophysiology

- Dogs: urolithiasis, neoplasia, prostatic disease, trauma and stricture
  - CaOx and struvite stones common in dogs
  - TCC of the bladder trigone and prostatic carcinoma
  - Strictures due to chronic urethritis, trauma during catheterization, damage to urethral epithelium due to passage of stone, tear/avulsion secondary to trauma, exuberant healing
- Cats: urolithiasis (CaOx), urethral plugs, functional obstruction from spasm, edema
  - FIC and associated inflammation of the LUT sets stage for obstruction

# URETHRAL OBSTRUCTION

Epidemiology/Signalment

- Males > females
- Patients that are predisposed to developing stones are greater risk

History and clinical signs

- LUT signs, vocalizing (cats), stranguria/dysuria, pollakiuria, unproductive attempts to void, discomfort
- Firm distended bladder common at presentation
- Stone palpated in pelvic urethra, prostatomegaly (dogs)
- > 24 hours – signs of systemic illness → dullness, bradycardia, hypothermia (cats)

# UROLITHIASIS

- Formation of uroliths is not a disease – but complication of several disorders
  - Oversaturation of urine with 1+ crystal precursors → crystals aggregation and lead to formation of macroscopic uroliths
    - Struvite, CaOx, urate, cystine
- Patient may present with:
  - Urinary tract obstruction
  - LUT signs w/o obstruction
  - No signs, incidental diagnosis
- If obstructed – may have vomiting, anorexia, abdominal pain, large/painful bladder, uroabdomen
- Ureteral obstruction – renal pain may be found

# UROLITHIASIS

Diagnosis

- Imaging most definitive tool
  - AXR, AUS +/- contrast (contrast and double contrast)
    - Determine presence, location, number, size, shape, density
- Urinalysis
  - Crystalluria does not confirm uroliths (concentrated urine, cooled/refrigerated urine)
  - USG, pH can determine chemical environment of urine
    - Alkaline: staph, enterococcus (urease producing bacteria) → struvite (dogs); cats can have sterile struvite uroliths
    - Acidic: E. coli; CaOx, purines, cystine stones

# UROLITHIASIS

Diagnosis

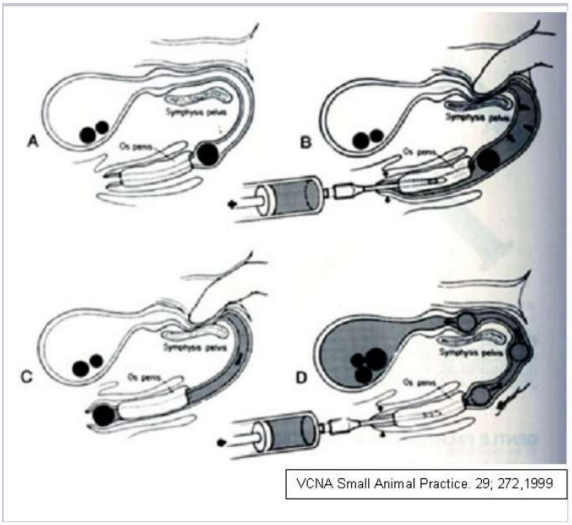
- Urine C/S
  - UTI may occur secondary to uroliths → mucosal damage induced by stones, incomplete urine voiding, micro-organisms entrapped in stone
  - Or may induce uroliths (struvite - dogs)
- Blood work
  - Look for underlying diseases (hyperCa, liver disease)
  - Obstructed – K, BUN/Cr, phos

*Not obstructed: refer to ACVIM Consensus Statement on treatment of canine/feline urolithiasis*

# UROLITHIASIS

Obstruction management

- Azotemia, hyperK, metabolic acidosis, dehydration may occur – stabilize accordingly
- Uroabdomen (management discussed elsewhere)
- Ureteral obstruction (more to come…)
- Relief of urethral obstruction from urolithiasis:
  - Ucath
  - Retrograde hydropulsion
  - Repeated cystocentesis
  - Cystostomy tube / pigtail
- Medical management – smooth muscle relaxation
  - Alpha 1 antagonists – prazosin, tamsulosin
  - TCA - amitriptyline



# URINARY DIVERSION IN THE ER…

# URINARY DIVERSION

- Urethral catheterization
  - Indications:
    - Relief of urethral obstruction +/- hydropulsion
    - Contrast imaging – cystourethrogram
    - Obtain UA samples
    - Bladder emptying in patients with urinary retention or temporary inability to void
    - Sanitary reasons
    - Aid with monitoring UOP (oligoanuria, severe polyuria)
  - Contraindications:
    - UTI, possible MDR (especially if in conditions were patients are at increased risk of UTI – DM, neuro)
    - Diarrhea – contamination

# URINARY DIVERSION

- Urethral catheterization
  - Complications
    - Trauma or tearing of the urethra
    - Kinking or knotting of the catheter
    - Catheter associated infection
      - 20% of female dogs catheterized in one study developed UTI; up to 52% in another
      - Infection associated with length of catheterization, age, administration of abx
      - Common isolates: E coli, enterobacter, staph, strep, pseudomonas, serratia, klebsiella +/- fungal infections
      - Prevention is key – aseptic technique, performing only if needed, little trauma

# URINARY DIVERSION

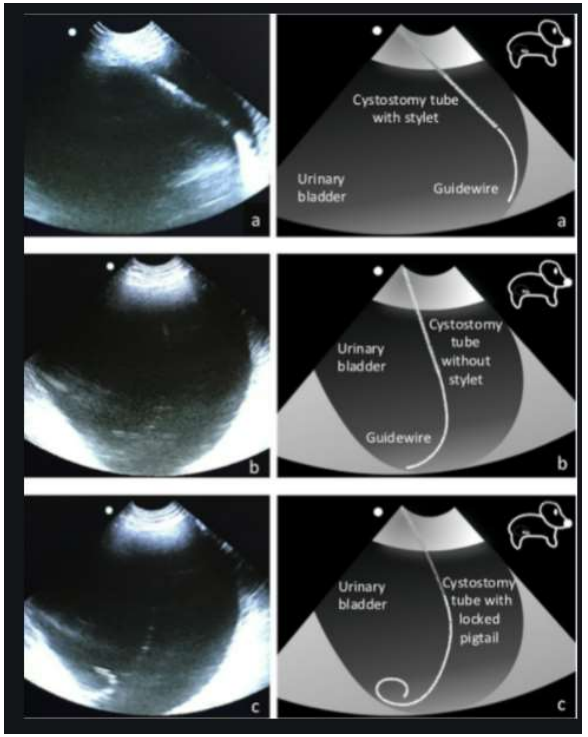
- Percutaneous antegrade urethral catheterization
  - If ucath cannot be passed or bladder rupture has occurred
  - Performed under GA
  - Patient placed in lateral recumbency, peripheral catheter inserted into bladder/decompressed → contrast urethrogram with fluoro → angled hydrophilic guidewire fluoroscopically guided percutaneously through the catheter into the bladder and urethra → urinary catheter inserted over the wire for retrograde catheterization + cystotomy tube
  - Complications:
    - Anesthetic complications
    - Inability to pass guidewire
    - Urine leakage

# URINARY DIVERSION

- Cystostomy tubes
  - Temporary or permanent
  - Part of long term management in patients with spinal cord or other neurologic disease, secondary to bladder dysfunction, post surgical diversion, obstructive neoplasia
  - Cystopexy to abdominal wall at time of placement
  - Various types: Foley, mushroom tipper catheters, low-profile gastrotomy tubes
  - Minimally invasive inguinal techniques and laparoscopic technique described for permanent placement
  - Emergency setting – percutaneous or suprapubic catheterization can be performed using fluoro or AUS guidance
    - Locking loop or Foley catheters can be placed

# URINARY DIVERSION

- Cystotomy tubes
  - Complications: as high as 49%
    - Inadvertent removal of tube or displacement from bladder most common
    - UTI
    - Urine leaking/uroabdomen
    - Hematuria
    - SQ infection
    - Fistula formation
    - Penetration of viscera/omentum
    - Bladder wall rupture
  - Case report on US-guided placement of pigtail cystostomy tubes with urethral obstruction (Culler JVECC 2019)



# URINARY DIVERSION

- Percutaneous nephrostomy tube
  - Indications:
    - Ureteral obstruction
      - Urgency depends on degree of metabolic derangements, urine production, cardiovascular stability
        - HyperK, severe metabolic acidosis, fluid overload – emergent intervention
      - Mostly placed in animals with bilateral disease
    - Once stabilized – definitive treatment may be pursued (stent, SUB, ureterotomy, ureteral reimplantation, ureteronephrectomy)
    - Locking loop pigtail catheters are used via modified Seldinger technique
    - No Ax needed, can be placed with AUS guidance – except for cats due to mobility of the kidneys → surgery and fluoro may be needed

# URINARY DIVERSION

- Percutaneous nephrostomy tube
  - Complications:
    - Pain
    - Hemorrhage
    - Hematoma formation
    - Hematuria
    - Infection
    - Urine leakage
    - Obstruction of the tube
    - Dislodgement
    - Intestinal injury
    - Septicemia
    - Pneumothorax
    - Hemothorax

# URINARY DIVERSION

- Peritoneal drainage
  - Locking loop pigtail catheters for uroabdomen
  - MILA chest tube catheter
- Complications:
  - Entrapment of other viscera
  - Penetration of viscera
  - Hemorrhage
  - Infection

# BACK TO UROLITHIASIS…

# UROLITHIASIS

Minimally invasive techniques

- Voiding urohydropulsion
  - Patient is sedated/anesthetized → catheter passed into bladder → bladder filled with sterile saline → urethra occluded → bladder squeezed as catheter is removed as patient is held vertically
  - Uroliths that are 1mm may be retrieved (male cats) and up to 10mm in female dogs
- Cystoscopy
  - Can allow for visualization of bladder pathologies (strictures, masses, calculi)
  - If stones are small enough can be removed via baskets and graspers

# UROLITHIASIS

Minimally invasive techniques

- Percutaneous cystolithotomy (PCCL)
  - Bladder approached through a small abdominal wall incision and temporarily fastened to incised linea alba
  - Cystoscope passed for stone removal via stab incision or laparoscopic port
- Lithotripsy
  - Laser fiber passed through operating channel of cystoscope
  - Fiber emits infrared light/wavelengths to fragment the calculi

# UROLITHIASIS

Surgical management

- Indications:
  - Obstruction of urine flow
  - Increase in number or size of stones
  - Persistent clinical signs
  - Lack of response to medical therapy (dissolution diet, antibiotics)
- Types of surgeries considered (for urethral obstruction)
  - PU surgery
  - Urethrotomy
  - Scrotal urethrostomy

# REFLEX DYSSYNERGIA

# REFLEX DYSSYNERGIA

- Resembles urinary obstruction but is a functional disorder of the voiding phase of micturition
- Urine voiding involves coordination of
  - Parasympathetic system to produce detrusor muscle contraction
  - Simultaneous relaxation of the internal sphincter (via inhibition of sympathetic tone of hypogastric n.) and external sphincter (inhibition of somatic pudendal n.)
- In dyssynergia –attempt to urinate results in contraction of bladder without relaxation of the internal and/or external sphincters
  - Internal – sympathetic dyssynergia – most common
  - External – somatic dyssynergia

# REFLEX DYSSYNERGIA

- Causes
  - Sexual excitement in males; castration may help improve signs
  - PU/PD – a full bladder, or when not taken out regularly, or if drinking a lot
  - UTI – spasm of the urethral sphincters due to inflammation
    - UTI – cause or consequence?
  - Surgery of the area of the bladder neck
  - Idiopathic – most common

# REFLEX DYSSYNERGIA

- Clinical signs and diagnosis
  - Young to middle aged, large breed, males may be more prone
  - History – important to gather info on pattern of urination, onset of signs and progression
    - Normal initiation of voiding → then decreased and sudden interruption of flow
    - Dysuria, stranguria, prolonged attempts to urinate, voiding in small, intermittent spurts which suddenly stop
  - Urinary catheter placement – no obstruction
  - UA
  - Radiographs + retrograde urethrocystogram can detect structural or anatomical abnormalities – look for stones, structure, neoplasms
    - Abnormal residual urine volumes
  - Often diagnosis of exclusion; urethral pressure profilometry; cystoscopy

# REFLEX DYSSYNERGIA

- Treatment
  - Prazosin – selective a1-adrenergic blocker
  - Phenoxybenzamine – nonselective a1 and a2 adrenergic blocker
  - Tamsulosin - a1a-adrenergic blocker that is more selective to the urinary tract (ie, prostatic urethra, bladder neck); more limited cardiovascular side effects
  - Diazepam, dantrolene, acepromazine – can be useful in dogs with somatic dyssynergia
  - Bethanechol – if overdistension is prolonged, chronic loss of detrusor muscle contractility may occur
- Prognosis – with appropriate therapy, can be favorable so long as severe complications such as bladder atony and UTIs are prevented

# FELINE URETHRAL OBSTRUCTION

# FELINE URETHRAL OBSTRUCTION

- Physical obstruction of the lumen of the urethra – calculus (20%), urethral plug (20%), stricture, neoplasia; spasm and edema play a role in up to 50% of cases
- Brought about by FIC – pathogenesis of FIC unclear
  - Sterile inflammatory process
  - Neurohormonal alterations – sympathetic and hypothalamic-pituitary-adrenal imbalance brought about by stressful situations → impairs blood flow and release of inflammatory mediates that cause edema, smooth muscle spasm, pain in LUT
- These conditions +/- physical obstruction from plug or stone are what leads to obstruction

# FELINE URETHRAL OBSTRUCTION

- Predisposing factors
  - Males - long, narrow urethra = more likely to develop obstruction
  - Different studies, different risk factors
    - Long hair cats
    - Multi cat household
    - Age
    - Diet
    - Indoor-outdoor status
    - Breed
    - Weight
    - Use of litter plan
    - Decreased water intake
    - Dry food diet
    - Neuter status

# FELINE URETHRAL OBSTRUCTION

Pathophysiology of obstruction

- Complete obstruction leads to accumulation of urine and pressure within the urethra and urinary bladder → can no longer distend → pressure necrosis and mucosal injury
- Pressure in urinary bladder transmitted up the ureters to kidney and Bowmans's capsule → reduction in GFR
- Within 24-48 hours the excretory ability ceases → accumulation/increase in BUN, Cr, phos, K, H → leads to clinical signs
- Uremia causes depression, nausea, vomiting, anorexia → decreased water intake + GI losses = dehydration and hypovolemia

# FELINE URETHRAL OBSTRUCTION

Pathophysiology of obstruction

- Retention of organic and inorganic acids → profound metabolic acidosis → denaturing of proteins, enzymatic dysfunction, catecholamine hyposensitivity
- Severe hyperK most life-threatening due to effects on electrical conduction of heart
  - HyperK raises the resting membrane potential and causes diminished Na conductance → rate of depolarization is significantly diminished → bradycardia, atrial standstill, cardiac arrest
  - K > 10-12  electrical activity can stop all together
- Significant illness within 24-48 hours, mortality in 3-5 days

# FELINE URETHRAL OBSTRUCTION

History and Clinical Signs

- Male cat – vocalizing, stranguria, unproductive urination in litter box
  - Difficult to differentiate from FIC
- Vomiting, lethargy, anorexia, abdominal pain, mentation changes, lateral recumbency
- Signs > 24 hours – systemically ill vs "healthy" blocked cat if caught early
- Dehydration, bradycardia, hypothermia
  - Hypothermia < 99.6 and bradycardia < 140 are strongly predictive of severe hyperK (>8) in cats with UO

# FELINE URETHRAL OBSTRUCTION

Initial stabilization

- IVC, bloods – PCV/TS,VBG, renal values
- IVF to dilute K even if ucath/bladder decompression cannot be performed right away
  - No difference in 0.9% NaCl vs balanced crystalloid
- ECG even if not bradycardic
  - Severe hyperK - prolonged P-R, diminished or absent P waves, wide QRS, tented T → atrial standstill, vfib, asystole
  - ECG changes not always associated with degree of hyperK
- HR < 140 – CaGluconate, regular inulin (0.5-1 U/kg), dextrose, terbutaline, albuterol. bicarb,
  - Ca does not reduce K but stabilizes electrical conduction

# FELINE URETHRAL OBSTRUCTION

## CYSTOCENTESIS - PRO

- Allows for immediate relief of pressure within urinary bladder → rapid restoration of GFR, relieves pain
- If no time to pass ucath – temporary relief
- Help with passing if ucath (back pressure relieved)
- Facilitates retrohydropulsion
- Improves bladder wall perfusion

## CYSTOCENTESIS - CON

- Rupture of bladder
- Uroabdomen due to distended and friable bladder
- Risk for hemorrhage
- Potential to delay unblocking
- Increased client cost

# FELINE URETHRAL OBSTRUCTION

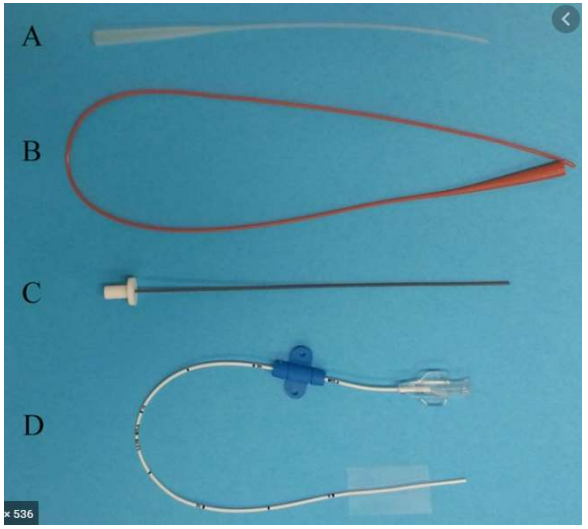
To cysto or not to cysto…

- Retrospective study (Hall JVECC 2014) – no complications in 47 cats that had cysto performed
  - 56% had evidence of abdominal effusion on AXR but not diagnosed with uroabdomen
  - No survival disadvantage or benefit
- Prospective study (Gerken JVECC 2020) – 1/3 of cats had US evidence of effusion prior to decompressive cysto, and 7 developed effusion after cysto – but not clinically relevant
- Prospective study (Reineke JAVMA 2021) – no evidence for or against cysto; cysto did not result in easier or quicker ucath placement; 93% of cats had pericystic effusion prior to cysto or ucath – cysto did not increase risk of urine leakage
- If cysto is performed – extension tubing, flexible collection system, adequate patient compliance needed

# FELINE URETHRAL OBSTRUCTION

Urinary catheter placement

- Heavy sedation/anesthesia needed
- Variety of catheter types – Tom Cat, Slippery Sam, red rubbers, MILA
- No set protocols
- Saline and lubricant flush solution used to facilitate passing of catheter
- Complications
  - Urethral trauma/tearing
  - Stricture



# FELINE URETHRAL OBSTRUCTION

Urinary catheter size

- Retrospective study – 3.5Fr may be best and have less risk of re-obstruction (Hetrick JAVMA 2013), though another paper did not replicate finding (Eisenberg JAVMA 2013)

- Davidow JVECC 2020 – 3.5Fr Argyle vs 3.5Fr RR did not have a difference in recurrence however small sample size

# FELINE URETHRAL OBSTRUCTION

Coccygeal blocks

- Simple, quick, may help reduce urethral tone
- Provides anesthesia to perineum, penis, urethra, colon, anus
- Blocks the pudendal, pelvic, and caudal nerves without loss of motor to the pelvic limbs
- Lidocaine in epidural space results in anesthesia within 5 minutes and lasts up to 60 minutes
- Low risk of complications as spinal cord ends around S1 in the cat (more cranial in the dog) – risk of penetrating the subarachnoid space is unlikely

# FELINE URETHRAL OBSTRUCTION

Coccygeal blocks

- Complications include infection, abscessation at site of injection, failure to provide analgesia, systemic absorption of lidocaine (rare)
- Contraindications for LS blocks: coagulation disorders, septicemia, pyoderma at site of injection, severe hypotension, anatomic abnormalities
  - Less of a concern for neurogenic hypotension (sympathetic blockade by anesthesia / increased vagal tone) as cranial spread is not far with coccygeal blocks
- Technique described O'Hearn JVECC 2011

# FELINE URETHRAL OBSTRUCTION

- Bupivacaine / bupivacaine-morphine coccygeal block also investigated (Pratt JVECC 2020)
  - Longer time to administration of rescue analgesia, easy,  no complications
  - No difference in urethral spasm, time to catheter placement, or ease of catheterization
    - Time to administer epidural and time to place urinary catheter were recorded separately

# FELINE URETHRAL OBSTRUCTION

Bladder lavage

- Bladder lavage with saline has not been found to make a difference in in-hospital RUO, length of catheterization, or LOH (Dorsey JAVMA 2019)

# FELINE URETHRAL OBSTRUCTION

Other Dx:

- CBC unlikely to provide any additional information beyond what PCV/TS offers
- UA: crystalluria, pH, hematuria, pyuria
- Urine culture unlikely to be of benefit initially – most cats do not have UTI
  - UTI may develop after catheter placement
  - Cooper JVECC 2019 – no cat had UTI diagnosed at time of UO but 13% developed bactiuria (strep and Pasteurella) – unknown if transient vs true UTI
  - NO! to empiric abx
- BP: may not always be an indicator for severity of disease – hypotension not identified in 28 cats with UO, though hyperK and hypoCa were present (Malouin JVECC 2007)
- AXR: to check for placement of ucath and uroliths

# FELINE URETHRAL OBSTRUCTION

Histopathology

- Postmortem: in cats with UO - 78% did not have an identifiable cause of obstruction (idiopathic) – Mauro JVECC 2020
  - Necrotizing cystitis found in 64% of case with submucosal hemorrhage in 100% and mural necrosis in 64%
  - Moderate-severe urethral lesions found in 21%
  - Moderate to severe renal lesions (tubulointerstitial nephritis) in 35%
  - Lymphocytic inflammation was identified in 11 of 14 (78%) bladders, 5 of 14 (35%) urethras, 8 of 14 (57%) kidneys, and 1 of 14 (7%) ureters
  - 21% had uroliths causing mechanical obstruction
  - Severity of bladder and renal lesions associated with degree of hyperK

# FELINE URETHRAL OBSTRUCTION

Treatment after de-obstruction

- Fluid therapy, monitoring UOP
  - Post obstructive diuresis can be profound (Frohlich JFMS 2015)
  - Occurred in 74% of cats within 4 hours of catheterization and 91% within 8 hours
  - Adjusted for fluid administration – 37% have POD
    - Fluid rate does play a role in urine output and may be driving force in diuresis

# FELINE URETHRAL OBSTRUCTION

- POD caused by downregulation of AQP2 in renal medullary collecting duct – resistance to ADH → acquired NDI
- Obstructed kidney cannot resorb Na → natriuresis occurs
- Secondary to accumulation of osmotically active substances in the blood, pressure necrosis, medullary washout

- POD > 2mL/kg/hr can occur - can be driven by fluid administration
  - Adjusting fluid therapy based on urine output may exacerbate post-obstructive diuresis and go beyond actual requirements in some patients
- However some patients can become severely dehydrated and hypovolemic during POD
- Inadequate urine production (<1mL/kg/hr) can be the result of dehydration, collection system, true oliguria from AKI (though very uncommon)

# FELINE URETHRAL OBSTRUCTION

Treatment

- Analgesia, sedation – cystitis, obstruction, catheter are all painful and can be associated with risk of re-obstruction
  - Opioids – buprenorphine, methadone
  - Acepromazine can decrease stress and agitation in stable patients and provide alpha antagonism, urethral relaxation

# FELINE URETHRAL OBSTRUCTION

Anti-spasmotics / alpha antagonism

- Prazosin selective for a1 phenoxybenzamine nonselective a1 and a2
- Male urethra is narrow and consists of smooth muscle proximally and striated muscle distal to prostate → most UO obstructions occur within the distal portion
  - A1 antagonists work on smooth muscle
- Obstruction in the proximal urethra may occur secondary to irritation, inflammation, spasm post catheterization and can contribute to RUO
- Prazosin works to inhibit a1 in smooth muscle without sedative effects of acepromazine
- 2 studies have found conflicting results – Hetrick 2013 found prazosin worked better than phenoxy but Reineke 2017 did not
  - Reineke – prazosin may lead to shortened catherization and LOH however
  - Studies were both flawed - Reineke underpowered to detect difference in prazosin vs placebo

# FELINE URETHRAL OBSTRUCTION

Treatment

- Abx? – no!  UTI occurrence is low and does not prevent catheter associated UTI
  - Can do UA/CS after catheter removal to determine if catheter associated UTI
- NSAIDS
  - No differences in NSAID vs placebo group for client assessed demeanor, food intake, painful behavior or RUO rates (22% vs 26%) (Dorsch JFMS 2016)
- Gabapentin for interstitial cystitis in humans
  - Neuropathic pain
  - Used as adjunctive treatment, may reduce opioids
  - Used alone – 48% improvement in pelvic pain (Cox Can Urol Assoc J 2016)
- Steroids – lymphocytes seen on histo?
  - Human study – steroids in combo with gabapentin, amytypilline and NSAID for transient, fluctuating, worsening pain or flare up (Jeong Int Neurourol 2012)

# FELINE URETHRAL OBSTRUCTION

- Treatment
  - Monitor lytes and renal values → significant improvement in 24 hours
  - HypoK can develop during post-obstructive diuresis
  - Leave catheter in place until urine is clear or improvement with major debris, clot, plugs – majority of studies document around 24-48 hours
  - Monitor for 12-24 hours to ensure spontaneous urination

- When to remove catheter?
  - Varying results on relationship between RUO and length of time catheterized
  - Some found shorter time led to more RUO (Eisneberg), other reports no association

# FELINE URETHRAL OBSTRUCTION

Other complications

- Severe anemia possibly necessitating a transfusion
  - Suspected to be due to hemorrhage into the bladder (Beer JVECC 2016)
  - Low occurrence rate 0.8%
  - More likely have had a previous obstruction and longer duration of clinical signs (median 3 days), more likely to have a murmur or gallop and lower BP (median 105mmHg), metabolic changes more severe (azotemia, lower pH)
  - Longer catheterization compared to nonanemic UO but LOH not significantly different
  - Possible causes: repeated events may predispose to hemorrhage from already severe, diffuse disease; longer duration of signs may lead to longer pressure necrosis and mucosal injury; more severe uremia/acid-base changes leading to platelet dysfunction
  - Monitor cats with significant hematuria closely

# FELINE URETHRAL OBSTRUCTION

Other complications

- Fluid overload (Ostroski JVECC 2017)
  - Aggressive fluid therapy may be needed to correct electrolytes, restore intravascular volume, flush debris from urinary system, maintain fluid balance during post-obstructive diuresis
  - Receiving a fluid bolus (higher cumulative fluid amount), development of a heart murmur, development of gallop sounds, and dysrhythmia at presentation were associated with development of FO
  - Associated with longer hospitalization and cost of care but not mortality

# FELINE URETHRAL OBSTRUCTION

Alternative management protocols

- Severely affected cats – hypothermia, bradycardia, lateral recumbency → euthanize
- Stable UO and owners cannot afford standard care -- analgesia, sedation, low stress environment, intermittent cysto can result in spontaneous urination without catheter (Cooper JAVMA 2010)
  - Small sample size
  - Treatment successful in 11/15 cats
  - 9/11 spontaneously urinated with 48 hours
  - 2/11 developed RUO within 3 weeks
  - 4/15 had treatment failure - 3 developed uroabdomen, 1 hemoabdomen
  - Average 3 cystos performed but 7 times in those failing treatment

# FELINE URETHRAL OBSTRUCTION

Other management protocols

- One time passage of catheter to clear obstruction, no IVF, then discharged with pain medication and prazosin (Seitz JAVMA 2018)
  - Increased recurrence of UO within 30 days compared to standard care with indwelling hospitalization (11% vs 31%) – 3.7x more likely to reobstruct
    - Better short-term results with inpatient care
  - Of the cats that did develop RUO (21% in total) – 95% occurred within the first 7 days (both outpatient and inpatient cats)
  - Urine color at time of catheter removal was associated with the development of RUO
  - 69% short term success rate – may be of benefit to owners with significant financial limitations
    - However traditional management carries success rate of 91-94%

# FELINE URETHRAL OBSTRUCTION

Home care

- High chance of recurrence immediately or in future
- Continued analgesia, sedation – acepromazine, buprenorphine, gabapentin for 5-7 days
- If significant spasming may also give prazosin
- Environmental strategies
  - Increase water intake - canned food, running water bowl
  - Diet
  - Environmental enrichment (toys, vertical perches, hiding spaces, litter pan number and hygiene, pheromones, etc)

# FELINE URETHRAL OBSTRUCTION

Prognosis

- Recurrence 15-58%
- 11-24% recurrence within 30 days, and most commonly within the first week
- PU may be considered – good long term QOL and minimal risk of recurrence but does not completely resolve signs – FIC, UTI, stricture
- Gerber JFMS 2008 – 91% survival to discharge, 51% had recurrent signs, 36% RUO, 21% ultimately euthanized → guarded long term prognosis

# URETHRAL TRAUMA

- Males more affected than females in dogs (85%) and cats (88.9%)
- Ischiocavernosus and ischiourethralis muscle anchors to the urethra and ischium in the male → less tolerant of traumatic traction and shearing forces
- Iatrogenic injury from ucath placement due to obstruction
- Most common cause of urethral injures in dogs and cats is trauma → 70% of cases in dogs and 55.6% in cats
  - Dogs: associated with pelvic fractures in 85.7% of cases
  - Cats: only 37.1% - blunt trauma without pelvic fracture can lead to significant urethral injury in cats

# URETHRAL TRAUMA

Patient evaluation

- Dysuria, stranguria, anuria, hematuria, abdominal distension, discomfort, anorexia, depression, hind limb, inguinal and perineal swelling or bruising
- Determine whether animal has suffered any trauma, urolithiasis, urethral catheterization or previous surgery near the urethra
- May be azotemic, hyperK, metabolic acidosis
  - Cr of peritoneal fluid > 2:1 of serum and K > 1.4:1 – diagnosis of uroabdomen is confirmed

# URETHRAL TRAUMA

Diagnosis

- Contrast radiography – retrograde urethrography for urethral rupture

Treatment

- Conservatively via second intention healing vs surgical repair or permanent urinary diversion
- Urethral healing requires good mucosal continuity and prevention of urine extravasation
- Mucosa heals in 7 days but regeneration of corpus spongiosum can take 3-5 weeks
- If complete transection of urethra /urothelium – healing is prevented and fibrosis can occur at urethral ends
- Urine is toxic and can lead to necrosis, increase in periurethral fibrosis → stricture formation
- Temporary urinary diversion is needed

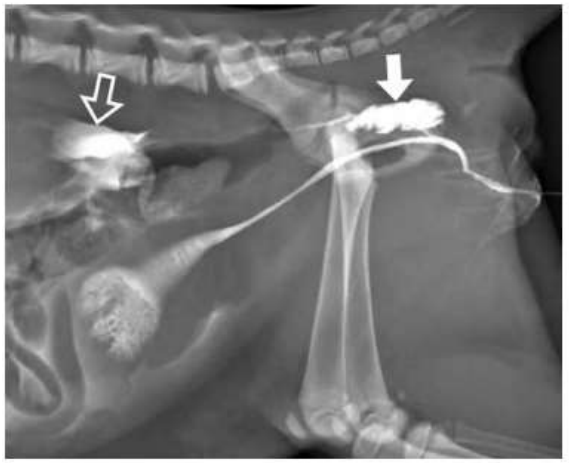


Figure 100.1 Retrograde urethrogram performed in an 8-week-old kitten with a history of urethral obstruction and catheterization. Notice the extravasation of contrast medium dorsally in the intrapelvic portion of the urethra (*closed arrow*), with contrast medium extending into the retroperitoneal space (*open arrow*). The cranial extension of contrast medium past the urethral disruption and into the bladder is consistent with a partial rupture.

# URETHRAL TRAUMA

Conservative management

- Temporary urinary diversion while mucosa heals by second intention
- Diversion using cystostomy tube, urethral catheter, both
- Catheter can act as a stent, and aid in alignment and healing
- Disadvantages: mechanical irritation, risk of ascending infection → promotes stricture formation
- Duration of diversion: optimum time is unknown – 3 to 37 days; minimum 7 days while mucosa regenerates
- Retrograde urethrogram should be performed to assess for ongoing leakage prior to catheter removal - another 3-5 days is needed; if persistent – need surgery
- Ureteritis may lead to transient hematuria or incontinence due to catheter placement
- UTI occurs in up to 80% of cases; abx may increase risk of resistant infection
- Success rate of 80% reported

# URETHRAL TRAUMA

Surgical management

- Indicated for complete transection or if conservative management fails
- Urethral anastomosis
  - Stricture formation is possible, or dehiscence due to tension
- Permanent urethrostomy
  - Permanent urinary diversion by creating a stoma to bypass area of injury
  - Higher complication associated with urethrostomies performed at more proximal locations
  - Dogs: scrotal urethrostomy preferred, less caveronous tissue, reduced hemorrhage
  - Cats: PU – amputating the penis and prepuce and generating a urethrostomy at the level of the ischium using the pelvic urethra

# URETHRAL TRAUMA

Complications

- Up to 57% in first 10 days and 27% long term
  - Infections, strictures, stenosis of stoma, dehiscence, incontinence, urine scalding, urine extravasation, development of LUTD
  - UTI can be MDR
- Stricture management
  - R&A, permanent diversion with cystostomy tube placed, medical management in mild cases
  - Balloon dilation, urethral stent placement
  - Stent complications include incontinence (12.5%), tissue ingrowth through stent, compression of the stent

# URETHRAL TRAUMA

Outcome

- Better outcome if iatrogenic
- Survival to discharge without long term complications – 83.3-91.3% for iatrogenic, 50-57.1% after trauma

# URETERAL OBSTRUCTION

# URETERAL OBSTRUCTION

- Causes of ureteral obstruction: ureteroliths (#1), dried solidified blood clots (8% of cats), ureteral strictures (25-30%), obstructive pyelonephrosis, obstructive neoplasia, severe ureteritis
  - Other causes: ureterotrauma, ureteral edema, accidental ligation, circumcaval ureter in cats
- 98% of feline upper tract stones are CaOx (50% of canine) = will not dissolve → need to pass spontaneously or be removed; urine needs to be diverted in mean time
- Obstruction can be complete or partial
  - Previously thought to allow benign neglect of partial obstruction – this has now changed, and immediate treatment is recommended
- Obstruction can be life-threatening when present bilaterally or in patients with pre-existing renal insufficiency

# URETERAL OBSTRUCTION

Pathophysiology

- Ureteral pressures increase immediately and can take over 24 hours after obstruction relief for the pressures to decrease
- Immediate increase in renal pelvic pressure (proximal ureter → renal pelvis → renal parenchyma) → pelvis dilation
- Increased pressure transmitted from renal pelvis to renal parenchyma (nephron and Bowman's capsule) → impaired or cessation of GFR
- Decrease in GFR also due to concurrent vasoactive mediator release, leukocyte influx, subsequent fibrosis
- Renal blood flow diminishes 60% over first 24 hours; 80% within 2 weeks

# URETERAL OBSTRUCTION

Pathophysiology

- Contralateral kidney will increase its GFR in response as long as that kidney is normal and has the potential for hypertrophic compensation
- The longer the obstruction → the more progressive and permanent the injury → may be irreversible
- Assume in cats that they are already renally compromised (most cats are azotemic – 25% renal function at time of diagnosis – suggesting compromised renal function of contralateral kidney)
- Partial obstruction results in less severe and slower nephron destruction – most cats are considered partial obstructions (based on ureteropyelography)
- After decompression – GFR returned to normal after 4 weeks after partial obstruction

# URETERAL OBSTRUCTION

Epidemiology / signalment

- Large scale studies lacking – mostly due to ureterolithiasis
- Breed predisposition in dogs with upper urinary tract calculi – Lhasa apsos, Mini Schnauzers, Shi Tzus, Yorkies; no difference in cats
- Urothelial malignancy – Scotties, Shelties, Beagles, Wire Haired Fox terriers, Westies

# URETERAL OBSTRUCTION

History and clinical signs

- Nonspecific – vomiting, lethargy, inappetence, weight loss, pollakiuria, polydipsia, hematuria, stranguria (though uncommon)
- Dogs: dysuria (incontinence, hematuria, polyuria, pollakiuria), signs of systemic illness
  - 77% associated with pyelonephritis and cystitis
- Ureteral colic – waves of sharp pain
- Abdominal pain – more common in acute obstructions; more common in dogs (capsule inflammation, stretch)

# URETERAL OBSTRUCTION

- PE may reveal asymmetric kidneys
  - Chronic obstruction – reduction in GFR and renal blood flow, progressive nephron loss, renal fibrosis, compensatory hypertrophy of unobstructed big kidney
- Pallor, anemia, murmur common in cats

# URETERAL OBSTRUCTION

Diagnostics

- CBC, chem, UA, culture, AUS, AXR
  - Cats often anemic (48%) – CKD
  - Dogs moderate to severe neutrophilia; thrombocytopenia – sepsis, immune mediated
  - Azotemia common
    - If other kidney is functioning – no azotemia
  - HyperPhos, hyperK, hyper/hypoCa common
  - UA: UTI – 8-30% of cats, 77% dogs
  - AUS: renal pelvic dilation, ureteral dilation, presence of uroliths, free fluid
    - Bilateral obstructions 19% cats, 12.5% dogs

# URETERAL OBSTRUCTION

Diagnostics

- Ideal to use AXR and AUS – AXR can count number and see size of stones, location, and see if nephrolithiasis is present; AUS – hydroureter, hydronephrosis, location of lesion; determine diameter of renal pelvis – planning interventional options
  - AXR 81% sensitivity in detecting ureteroliths in cats, 88% dogs
  - AUS 77% cats, 100% dogs
    - Combined 90% in cats
- Cats: 76% had nephrolith, 24% cystic calculi, median 2 calculi in affected ureter
- Cats with single stone – 44% were in proximal ureter and 41% in midureter
- Multiple stones – 61% hat stone in proximal ureter and 70% midureter
- Stones at UVJ more common in male cats
- L4 most commonly marked stone location in cats with 1 stone and most distal stone in cats with multiple stones
- Larger stones were caught more proximally (Nesser JFMS 2018)

# URETERAL OBSTRUCTION

Diagnostics

- Percutaneous antegrade pyelography
  - Helps determine localization of constriction and determining if partial vs complete
  - AUS guided intrarenal injection of contrast → images taken immediately, 5 min, 15 min with fluoro
  - Use has declined
- Retrograde urteropyelography
  - Via cystoscope and fluoro by cannulating UVJ and injecting contrast
  - Preserves nephrons / contrast induced nephropathy
- CT
  - Preoperatively when traditional surgical options are anticipated and if stone number and location are not clear in AXR and AUS
- GFR/scintigraphy

# URETERAL OBSTRUCTION

Treatment

- Medical management to stabilize prior to Ax
  - Stone passage has occurred in 8-17% of cases – may not move out of ureter but into different position to allow urine to pass
  - High risk of re-obstruction
  - <10% chance of complete passage
  - IVF, mannitol (0.25g/kg bolus then 1mg/kg/min CRI for 24 hours), ureteral muscle relaxer – as long as patient is not overhydrated, hyperK, oliguric, having progressive renal pelvic dilation)
    - IVF – maintenance rate of fluids using 0.45% NaCl + 2.5% dextrose (low Na)
- PAIN MANAGEMENT – stretch of ureteral wall and renal capsule activating mechanoreceptors → painful!

# URETERAL OBSTRUCTION

Treatment

- If no stone and there is clear pyuria/bacteriuria – start abx
  - Purulent plugs can cause obstruction in proximal ureter and medical management can be successful
- Ureteral muscle relaxants
  - Tamsulosin or prazosin for a1 blockade
    - Tamsulosin used in humans
    - Study in dogs comparing tamsulosin, prazosin, experimental B2 agonist, and verapamil showed the beta2 agonist was best and tamsulosin was second best
  - Amitriptyline – smooth muscle relaxer by opening of voltage gated K channels
  - Glucagon – not recommended
- If medical management fails at 24-48 hours – intervention needed; relieve hydrostatic pressure and stop permanent damage to renal parenchyma
- Blood transfusion – 19% of cats pre SUB, 14% after procedure (Berent JAVMA 2018)

# URETERAL OBSTRUCTION

Traditional surgical options

- Ureterotomy, neouretero-cystotomy, ureteronephrectomy, renal transplant
- High complications (>30%), high mortality (18-30%) depending on procedure performed (cats)
- Ureteronephrectomy not recommended especially as >30% of cats will develop CKD and may develop a stone in the other kidney/ureter – removal of the kidney instead of treating the underlying ureteral disease is not recommended
- Uretotomy or ureteral reimplantation are most commonly performed
  - Complications due to edema, recurrence of obstruction, stricture formation, tube leakage
  - 10% of cats that survived these complications needed to have a second procedure and 40% had recurrence of ureteral obstruction
  - Mortality rate of 25% in dogs; 17% of those that were followed needed additional surgery within 4 months due to stricture or recurrence of ureteroliths

# URETERAL OBSTRUCTION

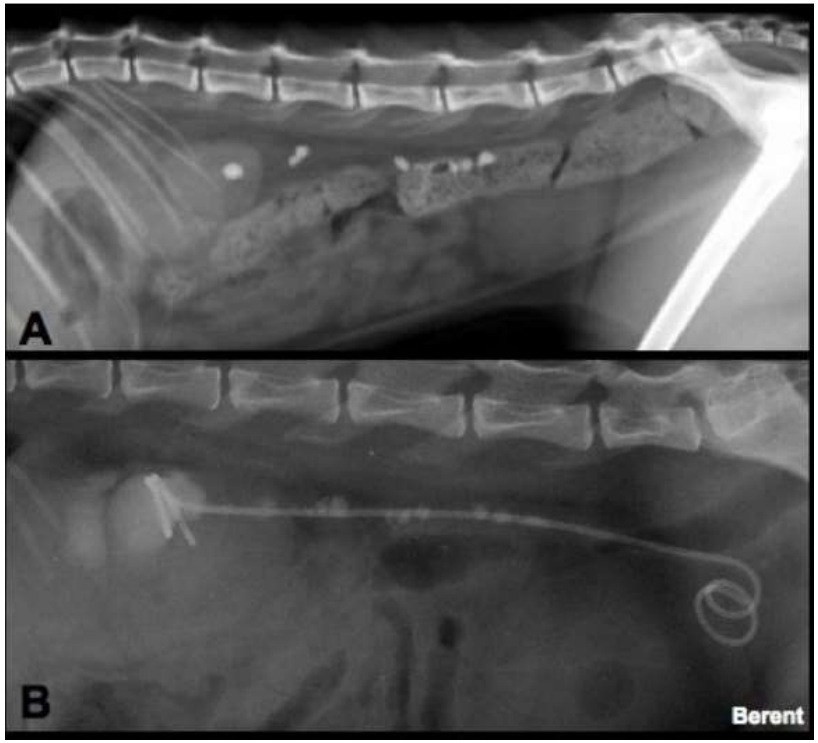
Interventional options

- Percutaneous nephrostomy tube placement
  - Quickly relieve obstruction and determine is adequate renal function remains before prolonged anesthesia for ureteral surgery, stent, SUB
  - Short term solution
  - Locking loop pigtail catheter can be used
  - High risk of postplacement complications (50%) – premature removal, dislodgement, urine leakage, poor drainage historically
  - Placed with US and fluoro guidance; percutaneously in dogs and surgically in cats
  - Renal pelvis >10mm needed to fit the locking loop

# URETERAL OBSTRUCTION

Interventional options

- Ureteral stenting
  - Indwelling double pigtail ureteral stent most common; can remain in place for months to years
  - Can be placed by cystoscopy and fluoro in dogs and surgical assistance and fluoro in cats
  - Success rate – 98% in dogs, 94% in cats



# URETERAL OBSTRUCTION

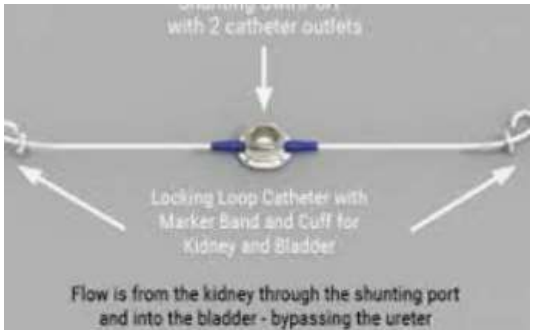
Ureteral stents

- Complications
  - Procedural – urine leakage, not common; can be very difficult to place in some patients; ureteral tear or perforation
  - Peri-operative (within first week) – mostly not related to procedure (CHF, pancreatitis)
  - Short term (1wk to 1 mo) – dysuria that may improve with steroids
  - Long term (>1mo) – pollakiuria, stent migration, ureteritis, tissue in-growth into the stent, chronic mid hematuria, UTI
  - Mortality rate <8% cats and <1% dogs

# URETERAL OBSTRUCTION

Interventional options

- Subcutaneous ureteral bypass (SUB) device
  - Created as an alterative to ureteral stents when a stricture was present or a stent could not be placed
  - Less complications than nephrostomy tube, ureteral stents
  - Placed with fluoro and surgery – locking loop nephrostomy catheter and cystostomy catheter connected to a subcutaneous shunting port
  - Lower mortality and long-term complications
  - Perioperative mortality rate was 6.6%; MST was 827 days with only 28% dying of suspected renal disease (cats)




# URETERAL OBSTRUCTION

SUB

- Post op complications include: leakage of urine, kinking of the catheter, blockage due to clots/purulent debris, stone deposition / mineralization, migration into GIT
- Blood clots in catheter usually occurred within 3.5 days and catheter exchange was needed in >50% of cases
- Mineralization 463 days after procedure
  - High postoperative iCa was significantly associated with SUB occlusion
- Ureteral patency can recur after placement
- Dysuria seen in 8% (compared to 38% in stents); chronic hematuria similar to stenting (12% vs 18%)
- UTIs – though many were enterococcus, asymptomatic and did not need treatment
- Placed more frequently in cats than dogs – dogs more amenable to surgery, stenting
- NO CYSTO on the side the SUB was placed and should only be done with AUS guidance
- Median hospitalization 4 days

# URETERAL OBSTRUCTION

Interventional options

- Extracorporeal shockwave lithotripsy
  - External shockwaves through water medium directed under fluoroscopic guidance in 2 planes
    - Ureteroliths must be < 3mm in cats and <5mm in dogs
  - Shocked at different energy levels to allow for implosion and powdering
  - Effective is creating passable stones in 85% of dogs
  - Effective only a small number of feline cases – stones are too small, embedded in mucosa

# URETERAL OBSTRUCTION

Post-operative/interventional management

- Substantial post-obstructive diuresis (>100mL/hr) → high fluid rates needed to maintain hydration
  - CHF (usually 2-5 days later), fluid overload also common
- Maintenance rate of enteral hydration (Pedialyte) at 60-120mL/day and if urine production is above this rate, also give low sodium maintenance fluids (0.45% NaCl + 2.5% dextrose) at 60mL/kg/day
  - Monitor lytes to prevent hyponatremia
- If patient is cardiovascularly stable and Cr is declining – rec to try to keep patient fluid intake slightly less than estimated or quantified urine production to prevent overhydration
- Pain management

# URETERAL OBSTRUCTION

Follow up management

- Monitor BUN/Cr
  - Persistent azotemia common in 40-50% of cats and 25-50% dogs; usually within IRIS stages 1-2 CKD
- Initial re-evaluation after SUB intervention is every 1-2 weeks, then at 1 month, then at 2-3 months for 1-2 years, then every 6 months
  - CBC, chem, UA/culture, T4, BP, AXR/AUS
  - Tetra-EDTA SUB flushes to prevent mineralization (and can also restore patency)
- Treat CKD – diet, phos binders, antacids, potassium citrate, ACEi for proteinuria, etc

# URETERAL OBSTRUCTION

Prognosis

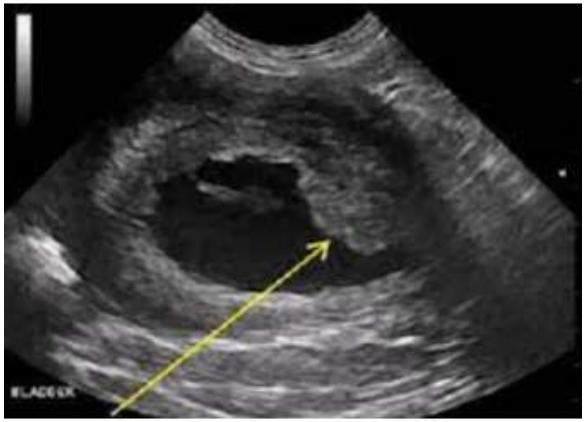
- Prognosis variable for renal recovery and persistence of patency after obstruction is relieved – depends on chronicity of obstruction, specie, cause of obstruction, post-op care
- Recovery can take weeks to months – so patience is needed

# TUMORS OF THE URINARY TRACT

# BLADDER TUMORS

Etiology/Pathophysiology

- Common in dogs, rare in cats
- TCC most common tumor of the urinary bladder in both species
  - Other neoplasms: SCC, leiomyosarcoma, leiomyoma, undifferentiated carcinoma, lymphoma, HSA, rhabdomyosarcoma, fibroma, other mesenchymal cell
- TCC mostly located at trigone in dogs and apex in cats
- Mass lesions can lead to thickening of the bladder wall and lead to partial or complete obstruction
- Urethral and prostatic involvement reported in 56% and 29%
- Overall metastatic rate is 50%



# BLADDER TUMORS - TCC

Epidemiology

- Primary malignancies of the LUT are rare in dogs (0.5-1% of all neoplasms)
  - TCC accounts for up to 75% of primary LUT tumors
- Aggressive neoplasm with moderate risk of mets to lungs and lymph nodes
  - Mets to skin reported in 10% of dogs (direct extension, hematogenous/lymphatic spread, iatrogenic – surgery, cysto)
- Higher risk in females
- Westies, Beagles, Dachshunds, Shelties, Scotties have 21x risk
- Mostly older 11-13yo
- Other risk factors: older flea products, lawn chemicals, obesity

# BLADDER TUMORS - TCC

History and clinical signs

- Stranguria, pollakiuria, hematuria, dysuria, incontinence
- Signs mat be present weeks to months prior to diagnosis
- Abdominal mass may be palpable, urethral thickening, sublumbar lymphadenopathy
- Rare paraneoplastic syndrome: HOD - lameness from bone metastasis

# BLADDER TUMORS - TCC

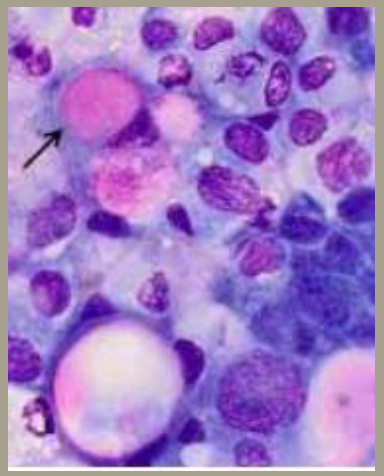
Diagnostics

- CBC, chem, UA
  - 30% cases malignant cells on urine sediment
  - Avoid cysto to prevent seeding
  - Concurrent infection possible – culture; can become increasingly resistant to treatment
- AXR: unrewarding unless lesion is mineralized; prostatomegaly, sublumbar LN enlargement, boney metastasis
- CXR: 17% pulmonary metastasis at time of diagnosis
- AUS: thickened bladder wall or mass lesion – ddx: other neoplasia, chronic cystitis, polypoid cystitis, granulomatous cystitis, calculi

# BLADDER TUMORS - TCC

TCC

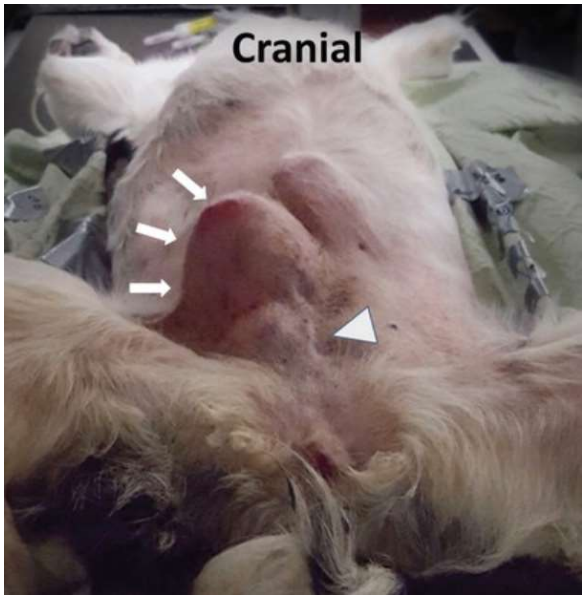
- Histopathology – gold standard
  - Traumatic u-cath, cystoscopy, cystotomy
- BRAF – genetic mutation highly sensitive for detecting TCC → voided urine samples
  - 15% do not have mutation
  - 5% false negative with Cadet BRAF plus; 0% false positive



# BLADDER TUMORS

Treatment

- Complete removal not possible due to location (unless completely at apex)
  - Dogs may develop multifocal tumor locations in bladder
- Obstruction – cystotomy tube, stents, SUB (if luminal obstruction due to infiltration)
  - 58/61 stent placement successful in relieving urethral obstruction
    - Can lead to incontinence
    - MST 78 days
  - JAVMA 2021 Merickel et al case report – cutaneous seeding after SUB placement



# BLADDER TUMORS

Treatment

- Radiation therapy – limited
  - Incontinence, pollakiuria, stranguria – affect QOL
  - Results with RT not better than medical therapy alone
- Chemo – COX inhibitor (piroxicam) alone or in combo with chemo
  - Can lead to remission or stable disease
  - Piroxicam – 21% remission rate (complete and partial), 59% stable disease, MST 240 day
  - Mitoxantrone + piroxicam – remission rate 35%, 46% stable disease, MST 291 days
  - Monitor response at 4-8 week intervals
  - Deramaxx has also worked
  - Other chemo – vinblastine, doxo, toceranib, metronomic oral chlorambucil

# BLADDER TUMORS

Prognosis

- Dependent on tumor size, location, mets
- MST are <1 year regardless of treatment
- Most have excellent QOL while on treatment
- Prognostic factors for survival: tumor stage at diagnosis, younger age, prostate involvement

# URETHRAL TUMORS

Urethral tumors

- TCC, SCC are most common
- Granulomatous urethritis (benign) must be differentiated

# RENAL TUMORS

Renal tumors

- Primary renal tumors are uncommon in cats and dogs
- Majority are malignant and more than half are epithelial in origin
- Cats: LSA most common and can affect both kidneys
  - 3.6% of all cats diagnosed with lymphoma and 22.3% of cats with large cell lymphoma
  - FeLV associated with the development of renal lymphoma
  - Mean age 7.7yo
  - Weight loss, pu/pd, pollakiuria, lethargy, hyporexia, dyspnea, hematuria
  - MST steroids along 42 days; LCHOP 203 days
  - 60% can achieve complete remission
  - Azotemia or anemia at diagnosis not associated with survival
  - Previously also associated with CNS lymphoma – but not found in more recent studies

# RENAL TUMORS

Renal tumors

- Dog: renal cell carcinoma; TCC, nephroblastoma, HSA, LSA other sarcomas possible
  - GSD female – slow growing dermal fibrosis, fibromas, cystadenoma and uterine tumors → Birt-Hogg-Dube syndrome in humans, rare – due to missense mutation
- Pulmonary mets in 16-34% dogs with primary renal tumors at time of diagnosis
- Nephroblastoma may occur at any age, other neoplasms – older dogs
- Signs: weight loss, polyuria, lethargy, hematuria, abdominal pain, signs of renal failure, possible renal enlargement on PE

# RENAL TUMORS

Diagnostics

- Mild anemia, marked neutrophilia, renal azotemia
- Paraneoplastic syndromes may include polycythemia, neutrophilia, HOD
- AUS can be highly suggestive, can consider FNA, renal biopsy, surgical biopsy

Treatment

- Nephrectomy for unilateral tumors or distant metastasis
  - MST for renal carcinoma with nephrectomy – 8mo

Negative prognostic factors – involvement of other organ, FeLV, renal failure

# REFERENCES


- Drobatz Chap 97, 98, 99, 100, 106, 187
- https://pubmed.ncbi.nlm.nih.gov/31989774/ Postmortem urinary tract changes in cats with urethral obstruction (Mauro JVECC 2020)
- https://pubmed.ncbi.nlm.nih.gov/21288294/ Coccygeal epidural with local anesthetic for catheterization and pain management in the treatment of feline urethral obstruction (O'Hearn JVECC 2011)
- https://pubmed.ncbi.nlm.nih.gov/26748857/ Severe anemia in cats with urethral obstruction: 17 cases (2002-2011) (Santoro Beer JVECC 2016)
- https://pubmed.ncbi.nlm.nih.gov/9673901/ Idiopathic detrusor-urethral dyssynergia in dogs: A retrospective analysis of 22 cases (JSAP 1998)

# REFERENCES


- https://pubmed.ncbi.nlm.nih.gov/28752928/ Retrospective evaluation of and risk factor analysis for presumed fluid overload in cats with urethral obstruction: 11 cases (2002-2012) (Ostroski JVECC 2017)
- •https://pubmed.ncbi.nlm.nih.gov/29889636/ Evaluation for association between indwelling urethral catheter placement and risk of recurrent urethral obstruction in cats (Seitz JAVMA 2018)
- https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7236633/ In-hospital medical management of feline urethral obstruction: A review of recent clinical research (Casford Can Vet J 2020)
- https://pubmed.ncbi.nlm.nih.gov/21463437/ Ureteral obstructions in dogs and cats: a review of traditional and new interventional diagnostic and therapeutic options (Berent JVECC 2011)
- https://pubmed.ncbi.nlm.nih.gov/30398425/ Use of a subcutaneous ureteral bypass device for treatment of benign ureteral obstruction in cats: 174 ureters in 134 cats (2009-2015). (Berent JAVMA 2018)