Management of Cystic Calculi

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Urolith Formation

- Urolith = aggregate of crystalline and occasionally non-crystalline solid substances within the urinary tract
- Supersaturated urine required for crystal formation
  - Initiation occurs with a submicroscopic crystal nucleus or, more often on an existing surface (i.e. cells, casts or other crystals), because requires a lesser degree of saturation
  - Crystal growth requires less degree of supersaturation than nucleus formation
  - Crystal growth occurs slowly while crystal aggregation can occur rapidly
- Delayed clearance of urine crystals required for urolith formation
Urolith composition

- Homogenous vs. layered vs. mixed (<70% of a layer composed of single crystalline type)
- Foreign material (plant, hair, suture, etc.) can act as a nidus
- Drugs and drug-metabolites (i.e., Sulfa metabolites)

![Urolith Composition Diagram]

Urolith types

- Calcium oxalate and struvite – most common
  - Account for almost 80% of all stones combined
- Increasing proportion of calcium oxalate recently (1985-2006)
  - In upper urinary tract most common urolith is calcium oxalate

![Urolith Types Chart]
Name that stone!

Calcium oxalate

- CaOx dihydrate = weddellite
- CaOx monohydrate = whewellite

- Signalment
  - Middle age (8-12 y.o)
  - Breed predisposition: Miniature Schnauzer, Lhaso Apso, Yorkshire Terriers, Bichon Frise, Pomeranian, Shih Tzu, Cairn Terrier, Maltese, Miniature Poodle and Chihuahua
  - More common in males than in females (~70% were males)
  - Neutered > intact
Calcium oxalate (continued)

- **Predisposing factors**
  - Hypercalciuria – increased urinary excretion of calcium
    - absorptive hypercalciuria (GI)
    - renal leak hypercalciuria – tubular damage
    - hypercalcemia hypercalciuria – hyperparathyroidism
  - Hyperoxaluria – from metabolites of dietary protein
  - Decreased natural inhibitors of urolithiasis
    - Citrate
    - Magnesium
  - Concurrent diseases
    - Hyperadrenocorticism
    - Chronic metabolic acidosis
    - Hypertriglyceridemia

- **Calcium oxalate (continued)**
  - More common than other mineral types in upper urinary tract
    - Almost all of feline nephroliths and ureteroliths are CaOx (~98%)
  - Not able to dissolve with dietary therapy, so mechanical removal necessary
  - Prevention of recurrence is based on dietary management +/- medications
  - Recurrence rates high, up to 50% within 3 years
Calcium oxalate (continued)

- Studies have shown that increasing dietary sodium decreases CaOx RSS, decreases urinary oxalate concentration, while increasing water intake, urine volume, and decreasing specific gravity.
- Relative supersaturation measures the potential for urine to dissolve and to form crystals of a particular type.
- Urinary pH is not a good predictor of CaOx RSS.
- Urinary pH is also a poor predictor of the risk of forming CaOx crystals and stones in cats.

Struvite

- Magnesium ammonium phosphate hexahydrate can often contain calcium phosphate/apatite.
- Signalment:
  - More common in females than males due to increased predisposition to bacterial cystitis (71-85% of struvites occur in females).
  - Breed predisposition: mixed breeds, Miniature Schnauzers, Shih Tzu, Bichon Frises, Miniature Poodles, Cocker Spaniels and Lhaso Apso.
Struvite (continued)

- Predisposing factors
  - Alkaline urine – pH >7.0
  - Canine struvite is associated with urease-producing bacterial cystitis
  - Urease cleaves urea into ammonia and bicarbonate
    - Ammonium binds with magnesium
    - Bicarbonate increases urine pH – decreases struvite solubility
Struvite (continued)

- More commonly located in lower urinary tract (95%) than upper urinary tract (5% - “staghorn”)
- Treatment options include dietary dissolution, medical dissolution, and mechanical removal
  - Important to control UTI at same time as fragmentation can cause release of bacteria
    - Can cause refraction to dissolution
    - Risk of urosepsis
  - Dietary/medical dissolution in males associated with risk of urethral obstruction

Staghorn calculi
Struvite (continued)

- Important to achieve an RSS of <1
- Urinary SO shown to dissolve struvites in cats in a median of 18 days (range of 10-56 days)

Urate/xanthine (purines)

- Signalment
  - Middle age and young animals (PSS), avg age 4 y.o.
  - Males > females (in Dalmatians)
  - Breed disposition: Dalmatians (40-70% of urate uroliths) and English bulldog, as well as Miniature Schnauzers, Shih Tzu and Yorkshire Terriers
Dalmatians and urate uroliths

- Almost all uroliths from Dalmatians were 100% urate
- Reduced rate of conversion of uric acid to allantoin leads to 10-60 x's increase in urinary uric acid excretion
  - Defective hepatic cell membrane transport system for uric acid (SLC2A9 transporter)
  - Reduced proximal tubular reabsorption of uric acid

Urate/xanthine (purines)

- Predisposing factors
  - Acidic urine – pH<5.5
  - High dietary purines
  - Severe hepatic dysfunction, especially portal vascular anomalies
    - High ammonium excretion
- Treatment options include dietary dissolution, medical dissolution, and mechanical removal
  - Xanthine uroliths most commonly secondary to treatment of urate uroliths (allopurinol)
  - Higher incidence of urethral obstruction than with other uroliths
    - Possibly due to male predisposition?
Cystine

- Composed of two molecules of amino acid cysteine linked by a disulfide bond
- Signalment
  - Males > females
  - Breed disposition: Mastiff, Australian Cattle Dog, English Bulldogs, Chihuahuas, Newfoundlands, Pit Bull Terriers and Dachshunds
- Geographically dependent – greater incidence in Spain and Sweden
- Acidic urine predisposes
- Treatment options include dietary dissolution and mechanical removal
- Recurrence is frequent, ranging from 1-36 months

Diagnosis of uroliths

- History – occasionally voided uroliths
- PE- occasionally can palpate in bladder or urethra
- Imaging
- Urinalysis and urine culture
- Stone analysis – requires removal of urolith (quantitative)
  - UC Davis Gerald V. Ling Urinary Stone Analysis Laboratory
  - Minnesota Urolith Center
  - Recurrent uroliths may have different composition
Imaging

- Survey abdominal radiographs
  - False negative if radiolucent or too small to detect (esp. cystine)
  - Urate, xanthine, cystine +/- struvite most radiolucent
  - Failure rates 2-27%
- Contrast radiographs
  - Pneumocystography or double contrast cystography
  - Failure rate 10%

Imaging (continued)
Imaging (continued)

- Ultrasound (image entire urinary tract)
  - Failure rate 6% (user-dependent)

Non-surgical removal

- Voiding urohydropropulsion
  - Females and males

- Cystoscopic retrieval with stone baskets
  - Must be smaller than dilated urethra

- Laser lithotripsy
  - Fragmentation of larger cystoliths of all types
  - Consider anesthesia time (>1 cm or >3 large uroliths, consider surgery)
Laser lithotripsy
Surgical mechanical removal

- Cystotomy
- Laparoscopic-assisted cystotomy/Percutaneous cystolithotomy

Lap-assisted cystotomy/PCCL
Dietary dissolution

- Canned food always preferential
  - Dilution
  - Increased voiding
  - Consider adding water to canned food
  - Goal is USG <1.020
  - Kibble just as effective?

- Urine alkalinization or acidification
- Added dietary Sodium
- Protein restriction (urate and cystine uroliths)

Dietary dissolution (continued)

- Dissolution diets
  - Hill’s s/d and Royal Canin S/O
  - Struvite, urates and cystine are dissolvable
  - Calcium oxalate cannot be dissolved

- Must be continued 1 month beyond radiographic resolution
- In conjunction with antibiotics for struvite uroliths (dogs)
- Contact time required therefore not effective for ureteroliths or uretheroliths
Dietary dissolution (continued)

- **Timing**
  - Dissolution time can be as short as ~1mo for struvite, longer for others
  - Dependent on surface area of stones

- **Common causes of failure**
  - Inadequate control of UTI with struvite
  - Mixed or layered uroliths with calcium oxalate
  - Poor owner compliance

- **Side effects**
  - Increase risk of calcium oxalate with acidifying diets (?)
  - Risk of urethral obstruction as calculi shrink

Specific dietary recommendations

- **Calcium oxalate (prevention only)**
  - Royal Canin S/O (moderate calorie also)
  - Hill’s u/d (high fat)
  - RC Gastrointestinal LF

- **Struvite**
  - Hill’s s/d – limit one month after dissolution
  - Hill’s c/d – maintenance diet
  - Royal Canin S/O – dissolution and maintenance
Diets (continued)

- Urate and Cystine
  - Hill’s u/d – low protein and alkalinization
  - Royal Canin Urinary UC for both
  - Royal Canin Vegetarian for Urates

- Royal Canin S/O can be fed long-term and designed to prevent calcium oxalate and struvite and works as a struvite dissolution diet, as well
- Homemade diets or custom formulations available

Non-dietary treatment - Oxalates

- Consider if persistent calcium oxalate crystalluria or recurrence with dietary therapy
- If hypercalcemia, treat underlying cause
- Thiazide diuretics
  - Hydrochlorothiazide (2 mg/kg BID)
  - Reduce calcium urinary excretion
- Potassium Citrate
  - If urine pH< 7.0, then 50-75 mg/kg BID
  - Increased citrate as an inhibitor
  - Increases urine pH – increased solubility of calcium oxalate
Non-dietary treatment - Urates

- Allopurinol – synthetic isomer of hypoxanthine
- Inhibits action of xanthine oxidase
- Decreased uric acid production
- 15 mg/kg BID (reduce with renal failure)
- Can lead to formation of xanthine calculi

Thanks Royal Canin!!

Canine and Feline Health Nutrition
Questions?

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Name that stone...