Dear Veterinary Health Care Team,

According to recent studies, feline lower urinary tract disease (FLUTD) is the most common reason that clients seek veterinary care*. In this second edition of Managing Crystalluria & Urolithiasis, Hill’s is providing the latest information on the management of this condition.

Since 2001, the percentage of feline struvite uroliths has increased, while the percentage of calcium oxalate uroliths has decreased. Research we conducted in 2006 at the Minnesota Urolith Center showed that 50% of feline uroliths are struvite and 39% are calcium oxalate. This change in occurrence underlines the need for accurate urolith analysis.

Managing Crystalluria & Urolithiasis may be used as a reference tool to help with diagnosis and management of lower urinary tract disease in both cats and dogs. It contains updated flowcharts, some of which incorporate information about new Hill’s® Prescription Diet® c/d® Multicare Feline pet food.

Thanks to an educational grant from Hill’s, the Minnesota Urolith Center continues to provide urolith analysis to you and the veterinary health care team.

This updated guide is designed to help you with diagnosis and management of urinary problems in your canine and feline patients.

Sincerely,

Carl Osborne, DVM, PhD, DACVIM
Jody Lulich, DVM, PhD, DACVIM

*Veterinary Economics, September 2005.
GENERAL POINTS

CRYSTAL IDENTIFICATION

- Perform microscopic examination of sediment from a fresh urine sample at room temperature
- At times, crystals of more than one type can be present
- Common crystals are struvite or calcium oxalate
- Crystals can vary considerably in size and shape
- Distinguish between *in vivo* and *in vitro* crystalluria

UROLITH APPEARANCE

- Only quantitative analysis can reliably determine the composition
- Prolonged exposure to blood pigment may darken the surface
- Changes in the urine during formation of a urolith can result in it having a central nidus of a different composition than the surrounding layers

AT-RISK PROFILE

- This section lists factors predisposing a dog to each type of crystalluria and urolithiasis

INITIAL MANAGEMENT

- Lists priority procedures for relief of clinical signs

LONG-TERM MANAGEMENT

- Details nutritional recommendations for prevention of occurrence and recurrence in high-risk dogs

Flowcharts are provided to give you more detailed diagnostic pathways and options for nutritional management of certain types of LUTD.

Additional support from Hill’s Pet Nutrition, Inc.

Hill’s Veterinary Consultation Service

Hill’s Veterinary Consultation Service (VCS) talks with more than 16,000 clinics each year, providing total case management, nutritional counseling and product support for both domestic and international veterinary hospitals at no cost. Veterinarians and health care team members contact Hill’s VCS with a wide variety of disease management and nutrition cases, including struvite urolithiasis, calcium oxalate urolithiasis and lower urinary tract disease.

1-800-548-VETS (8387)
FAX: 1-800-548-VFAX (8329)
E-MAIL: vet_consult@HillsPet.com

In 2005, researchers analyzed 32,885 canine uroliths and found:

- *Minnesota Urolith Center, 2005.*

<table>
<thead>
<tr>
<th>Composition</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Struvite</td>
<td>38%</td>
</tr>
<tr>
<td>Calcium oxalate</td>
<td>42%</td>
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<tr>
<td>Purine</td>
<td>5%</td>
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<tr>
<td>Cystine</td>
<td>1%</td>
</tr>
<tr>
<td>Compound, mixed, miscellaneous</td>
<td>14%</td>
</tr>
<tr>
<td>Calcium oxalate</td>
<td>38%</td>
</tr>
<tr>
<td>Struvite</td>
<td>42%</td>
</tr>
</tbody>
</table>
**CRYSTAL IDENTIFICATION**

- Characteristically colorless, coffin-lid shaped prisms, of varying sizes

**UROLITH IDENTIFICATION**

- Most common type of urolith in female dogs
- Characteristically multiple, round or faceted; creamy to gray in color
- Radiopaque

- Stone appearance may vary; quantitative analysis needed to identify urolith(s)

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**AT-RISK PROFILE**

- Usually urinary tract infection with urease-producing bacteria, particularly staphylococci
- Females
- Urine retention
- Low water intake

- Miniature Schnauzer, Miniature Poodle, Cocker Spaniel, Bichon Frise
- Diabetes Mellitus
- High-protein or high-phosphorus foods
- Less acidic urine

**INITIAL MANAGEMENT**

- Consider removing stones via voiding urohydropropulsion, lithotripsy or surgery, or dissolve uroliths using Hill’s® Prescription Diet® s/d® Canine pet food

  **Check the Hill’s Key to Clinical Nutrition for contraindications**

- Administer antibacterial therapy for UTI throughout dissolution period
- Radiograph monthly to check stone size, density and location
- If no change in stone size and density after 8 weeks, consider alternatives

**LONG-TERM MANAGEMENT**

- Monitor for and treat confirmed UTI
- Recommend Hill’s® Prescription Diet® c/d® Canine pet food or w/d® Canine pet food
- w/d® Canine pet food is low in calories and fat for obese-prone dogs
- Encourage water intake
- Avoid prolonged periods of urine retention

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**STRUVITE (MAGNESIUM AMMONIUM PHOSPHATE)**

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1-800-548-VETS (8387) · HillsVet.com
**CALCIUM OXALATE**

### CRYSTAL IDENTIFICATION

- Dihydrate crystals are octahedral
- Monohydrate crystals can be dumbbell or lathe-shaped, with pointed or rounded ends
- Colorless

### UROLITH IDENTIFICATION

- May have rough irregular surface
- May be round; sometimes darkened by blood pigment
- Radiopaque
- Stone appearance may vary; quantitative analysis needed to identify urolith(s)

### AT-RISK PROFILE

- Males
- Older dogs
- Miniature Schnauzer, Miniature Poodle, Shih Tzu, Bichon Frise, Lhasa Apso, Yorkshire Terrier
- High-protein foods
- Low-water intake
- Urine retention
- Aciduria

### INITIAL MANAGEMENT

- Consider removing stones via voiding urohydropropulsion, lithotripsy or surgery
- In absence of clinical signs, serial monitoring may be an alternative to immediate stone removal
- Follow up with immediate post-removal radiography
- Submit uroliths for quantitative analysis to confirm stone type
- Then proceed to long-term management

### LONG-TERM MANAGEMENT

- Recommend Hill’s® Prescription Diet® u/d® Canine pet food
- Contact VCS for nutritional recommendation for obese or obese-prone dogs
- Check the Hill’s Key to Clinical Nutrition for cases where not indicated and for long-term use guidelines
- Encourage water intake
- Urinalysis monthly at clinic; USG should be <1.020
- Avoid prolonged periods of urine retention

**Contact**

Hills Vet Services
1-800-548-VETS (8387) · HillsVet.com
**CRYSTAL IDENTIFICATION**

- Ammonium urate (ammonium acid urate, ammonium biurate) crystals can be amorphous or thorn-apple shaped
- Urate crystals are often tan in color

- Naturally occurring uric acid crystals are rare
- Sodium urate can be needle-shaped; however, other substances can also form needle-shaped crystals

**UROLITH IDENTIFICATION**

- Characteristically smooth surface with concentric layers of mineral
- Radiolucent or poorly radiopaque

- Stone appearance may vary; quantitative analysis needed to identify urolith(s)

**AT-RISK PROFILE**

- Males
- Dalmatian, English Bulldog, Yorkshire Terrier
- Portovascular anomalies

- High-protein (purine) foods
- Low-water intake
- Urine retention

**INITIAL MANAGEMENT**

- Perform fasting serum chemistry panel and hepatic function tests (i.e. provocative bile acids)
- Consider removing stones via voiding urohydropropulsion, lithotripsy or surgery, or attempt to dissolve with Hill’s® Prescription Diet® u/d® Canine pet food and allopurinol
- Provide appropriate treatment for underlying diseases if present (i.e. portovascular anomalies)

**Dissolution:**

- Recommend u/d® Canine pet food and allopurinol (don’t give allopurinol without reducing purine intake)
- Check stone size, location and density monthly
- Appropriate antibacterial therapy only if urinary tract infection (UTI) present
- Then proceed to long-term management

**LONG-TERM MANAGEMENT**

- Recommend Hill’s® Prescription Diet® u/d® Canine pet food
- **Check the Hill’s Key to Clinical Nutrition for cases where not indicated and for long-term use guidelines**
- Target urine pH 7.0-7.7
- Urinalysis monthly at clinic; USG should be <1.020
- Encourage water intake
- Avoid prolonged periods of urine retention
- If necessary, consider low dose allopurinol® for management

- Contact VCS for nutritional recommendation for obese or obese-prone dogs

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**CRYSTAL IDENTIFICATION**

- Ammonium urate (ammonium acid urate, ammonium biurate) crystals can be amorphous or thorn-apple shaped
- Urate crystals are often tan in color

- Naturally occurring uric acid crystals are rare
- Sodium urate can be needle-shaped; however, other substances can also form needle-shaped crystals

**UROLITH IDENTIFICATION**

- Characteristically smooth surface with concentric layers of mineral
- Radiolucent or poorly radiopaque

- Stone appearance may vary; quantitative analysis needed to identify urolith(s)
OTHER CRYSTALS THAT MAY BE SEEN

- Cystine
- Bilirubin
- Xanthine (identical in appearance to ammonium urate)
- Cholesterol
- Sulfa Drugs
- Beware of artifacts, such as microscope slide chips
Probable diagnosis of urolith(s) as struvite

- Perform complete urinalysis¹
- Urine culture and bacterial susceptibility (MIC if possible)
- Obtain 12-hour fasting serum chemistry panel
- Perform radiography²

Does the dog have any of these conditions?³
- Cardiac, liver, renal disease or other sodium retention problems
- Pancreatitis, history of pancreatitis or other abnormalities of fat metabolism
- Obesity, diabetes or other fiber-responsive condition
- Heart failure or hypertension
- Hyperlipidemia

Yes No

If unable to remove stones by voiding urohydropropulsion, lithotripsy or surgery:
- Feed Hill's® Prescription Diet® s/d® Canine pet food exclusively⁹

If unable to remove stones by voiding urohydropropulsion, determine best option:¹° DISSOLUTION OR SURGERY

Remove stones via voiding urohydropropulsion, lithotripsy or surgery:
- Feed Hill's® Prescription Diet® w/d® Canine pet food⁶

Dissolution Protocol
- Feed Hill's® Prescription Diet® s/d® Canine pet food (no longer than 6 months)
- Administer antibiotics for UTI during entire dissolution period
- Radiograph monthly to check stone size, density and location

Are stones dissolving?

Yes
- If no change in stone size or density after eight weeks, surgically remove

No
- Continue antibiotics and food for one month beyond apparent radiographic dissolution

Monitor progress while on Hill's® Prescription Diet® s/d® Canine pet food
At Home: Check urine pH weekly¹⁰
At Clinic: Monthly urinalysis¹¹ and urine cultures; check urine pH and monitor for crystalluria
- Urine Specific Gravity (USG) should be <1.020 while on s/d® Canine pet food
- Treat confirmed UTI
- Check urine pH, target is 5.9-6.1

Urine pH >7.0
- USG or urine pH not within target
  - Satisfactory results. Proceed to long-term management
- Urine pH <5.9
  - Monitor for CaOx
  - Verify dietary compliance⁷
- USG >1.020
  - Check BUN; BUN should be <10 mg/dl; check dietary compliance if BUN >10-15 mg/dl¹²
  - Feed s/d® Canine pet food exclusively⁶

UTI:
- Check for persistent UTI and continue antibiotics
- Consider adding Lithostat if necessary¹²

Struvite crystals:
- Check dietary compliance
- Feed s/d® Canine pet food exclusively⁶

Long-Term Management:
- Control bacterial UTI
- Monitor urine pH¹³ weekly at home; target pH is 6.0-6.5
- Urinalysis monthly;¹¹ check for crystalluria and evidence of UTI

Urine pH <5.9

NOTE: Do not feed Hill's Prescription Diet® s/d® Canine pet food for more than six months¹²

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Urolith(s) detected; identified as possible calcium oxalate

- Perform complete urinalysis
- Perform radiography
- Obtain stones by voiding urohydropropulsion, lithotripsy or surgery
- Follow up with immediate post-removal radiography
- Perform quantitative analysis to confirm stone type
- Obtain fasting serum chemistry panel; is serum calcium high?

High-serum calcium levels

Urolithiasis may be one consequence of hyperparathyroidism or other disease
- Identify and treat underlying disease

Normal serum calcium levels

Urolithiasis may be associated with increased urine levels of calcium or oxalate, or decreased urine levels of citrate
- Unknown etiology

DOES THE DOG HAVE ANY OF THESE CONDITIONS?
- Obesity
- Hyperlipidemia
- Hypoproteinemia, hypoalbuminemia
- Pancreatitis, history of pancreatitis, or at risk of pancreatitis
- Fiber-responsive disease condition
- Lymphangiectasia

Continued at top of next page

Flowchart

No

- Feed Hill’s® Prescription Diet® u/d® Canine pet food
- Encourage water intake (i.e. canned food)
- Monitor urine pH weekly at home
- Check urine pH at clinic monthly and monitor for crystalluria
  - If average urine pH <7, check dietary compliance to confirm dog is eating u/d® Canine pet food exclusively and add potassium citrate
  - Urinalysis monthly at clinic; USG should be <1.020 when fed u/d® Canine pet food

Yes

- Feed Hill’s® Prescription Diet® w/d® Canine pet food; and add potassium citrate
- Encourage water intake
- Monitor urine pH weekly at home
- Check urine pH at clinic monthly and monitor for crystalluria
  - If average urine pH <7, add or adjust dose of potassium citrate

Proceed To Long-Term Management

Satisfactory results. Proceed to long-term management

USG ≥1.020

- Check BUN, should be ≤10-15 mg/dl
- Check dietary compliance if BUN >10-15 mg/dl

Long-Term Management

At appropriate intervals:
- Verify dietary compliance (BUN ≤10-15 mg/dl; USG <1.020 when fed u/d® Canine pet food)
- If CaOx crystalluria persist or recurrent stones are detected by radiograph or ultrasonography, contact Hill’s Veterinary Consultation Service; as last resort consider hydrochlorothiazide
- Every 6 months, check serum total protein and albumin
Probable diagnosis of urolith(s) as ammonium urate

- Perform complete urinalysis
- Urine culture and bacterial sensitivity (MIC if possible)
- Radiography (double contrast) or ultrasound
- Treat confirmed UTI
- Perform fasting serum chemistry panel and hepatic function tests (i.e. provocative bile acids)

Evaluate liver function
- Consider breed (Dalmatian vs other)

Non-Dalmatian breeds; all dogs with hepatopathy
- Treat underlying hepatopathy if present
- Remove stones via voiding urohydropropulsion, lithotripsy or surgery; perform quantitative analysis of stones
- Follow up with immediate post-removal radiography
- Feed Hill’s Prescription Diet w/d Canine pet food

Dissolution is best option:
- Submit stones for quantitative analysis
- Follow up with immediate post-removal radiography
- Feed Hill’s Prescription Diet u/d Canine pet food
- Give allopurinol for one month beyond surgery, and discontinue when crystals are gone

Proceed to Monitor Progress

Dissolution is best option:
- Feed u/d Canine pet food and add allopurinol
- Appropriate antibacterial therapy only if urinary tract infection (UTI) is present
- Check stone size, location and density monthly (use double contrast studies)

Are stones dissolving?
- If no change in stone size or density after eight weeks, consider surgically removing

Continue dissolution protocol:
- Continue feeding u/d Canine pet food
- Give allopurinol for one month beyond dissolution and discontinue when crystals are gone

Proceed to Monitor Progress

Continue dissolution protocol:
- Treat underlying hepatopathy if present
- Remove stones via voiding urohydropropulsion, lithotripsy or surgery; perform quantitative analysis
- Follow up with immediate post-removal radiography
- Feed Hill’s Prescription Diet w/d Canine pet food

Monitor progress:

At home: Check urine pH weekly
At clinic: Monthly urinalysis: urine pH, USG, crystalluria; average urine pH should be 7.0-7.7; USG should be <1.020

Crystalluria or USG >1.020
- Check BUN, should be <10-15 mg/dl while eating u/d Canine pet food
- Check dietary compliance
- Add low dose allopurinol if crystalluria persists while feeding u/d Canine pet food

Average Urine pH <7.0
- Check dietary compliance
- If urine is acidic, alkalinize it with potassium citrate

Long-Term Management:
- Continue monthly UA; every 6 months, fasting serum chemistry panel, serum protein, albumin, echocardiogram
- Once past active phase of stone formation, consider changing food to Hill’s Prescription Diet k/d Canine pet food and continue to monitor regularly

*Note: allopurinol may induce xanthine urolith formation

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CRystal identification
- Perform microscopic examination of sediment from a fresh urine sample at room temperature
- At times, crystals of more than one type can be present
- Common crystals are struvite or calcium oxalate
- Crystals can vary considerably in size and shape
- Distinguish between in vivo and in vitro crystalluria

Urolith appearance
- Only quantitative analysis can reliably determine the composition
- Prolonged exposure to blood pigment may darken the surface
- Changes in the urine during formation of a urolith can result in it having a central nidus of a different composition than the surrounding layers

At-risk profile
- This section lists factors predisposing a cat to each type of crystalluria and urolithiasis

Initial management
- Lists priority procedures for relief of clinical signs

Long-term management
- Details nutritional recommendations for prevention of occurrence and recurrence in high-risk cats

Flowcharts are provided to give you more detailed diagnostic pathways and options for nutritional management of certain types of LUTD.

In 2006, researchers analyzed 10,093 feline uroliths and 551 urethral plugs and found:

- **Feline Uroliths**: 50% struvite, 39% calcium oxalate, 5% purine, 6% other
- **Feline Urethral Plugs**: <1% calcium oxalate, 88% struvite, 2% other, 9% matrix

ADDITIONAL SUPPORT FROM HILL’S PET NUTRITION, INC.

Hill’s Veterinary Consultation Service
Hill’s Veterinary Consultation Service (VCS) talks with more than 16,000 clinics each year, providing total case management, nutritional counseling and product support for both domestic and international veterinary hospitals at no cost. Veterinarians and health care team members contact Hill’s VCS with a wide variety of disease management and nutrition cases, including struvite urolithiasis, calcium oxalate urolithiasis and lower urinary tract disease.

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FAX: 1-800-548-VFAX (8329)
E-MAIL: vet_consult@hillsPet.com
CRystal Identification

- Characteristically colorless, coffin-lid shaped prisms, sometimes with square forms
- Less typical forms include hexagonal and octagonal forms (which might be mistaken for cystine) and narrow, pointed crystals

Urolith Identification

- Most common type of urolith in cats; if sterile (>95% of cases) often appears as an oval wafer or disc (above), occasionally as a jagged, quartz-like structure, resembling calcium oxalate dihydrate
- Usually creamy or light brown color (darkens with prolonged exposure to blood pigment)
- Most uroliths occur in the bladder
- Radiopaque
- Stone appearance may vary; quantitative analysis needed to identify urolith(s)

AT-Risk Profile

- Younger cat – under 5 years old
- Overweight/obese/inactive
- Low-water intake
- Less acidic urine (pH >6.5)
- Sometimes (<5%) urinary tract infection with urease-producing bacteria, particularly staphylococci
- Urethral Plugs: Struvite is the principal mineral in urethral plugs, which occur almost solely in males – particularly neutered

Initial Management

- Dissolve using Hill’s® Prescription Diet® s/d® Feline pet food
- Perform monthly urinalysis and radiography to monitor progress of dissolution, stone size, density and location
- Continue s/d® Feline pet food for one month beyond radiographic evidence of dissolution
- If no change in stone size and density after 8 weeks, consider alternatives
- Appropriate antibacterial therapy only if UTI present
- After dissolution, proceed to long-term management

Long-term Management

- Consider recommending Hill’s® Prescription Diet® c/d® Multicare Feline pet food or w/d® Feline pet food
- w/d® Feline pet food is low in calories and fat for obese-prone cats
- Encourage water intake (i.e. canned food)§
- Monitor urine pH and check for appearance of crystals (i.e. calcium oxalate, struvite)
- Contact VCS for nutritional recommendation for obese cats
**CRYSTAL IDENTIFICATION**

- Above photo features both monohydrate and dihydrate crystals; monohydrate crystals vary in size and shape, usually dumbbell or oval
- Dihydrate crystals vary in size, but octahedral in shape; appear as “envelopes,” (i.e. squares with prominent diagonals) which distinguishes them from struvite crystals
- Pure monohydrates are characteristically small, smooth and spherical
- Usual tan or brown color
- Radiopaque
- Nephroliths very likely to be calcium oxalate
- Mixed monohydrate/dihydrate uroliths have a characteristic irregular quartz-like appearance (above) or irregular surface
- Usually white or creamy color
- Radiopaque
- Stone appearance may vary; quantitative analysis needed to identify urolith(s)

**AT-RISK PROFILE**

- Older cat – over 7 years
- Overweight/obese/inactive
- Persian, Burmese and Himalayan
- Low water intake
- More acidic urine

**INITIAL MANAGEMENT**

- Consider surgical removal of stones (voiding urohydropropulsion or lithotripsy in female cats)
- Follow up with immediate post-removal radiography
- Submit uroliths for quantitative analysis to confirm stone type
- Appropriate antibacterial therapy only if urinary tract infection (UTI) present
- Then proceed to long-term management

**UROLITH IDENTIFICATION**

- Pure monohydrates are characteristically small, smooth and spherical
- Usual tan or brown color
- Radiopaque
- Nephroliths very likely to be calcium oxalate

**LONG-TERM MANAGEMENT**

- Consider recommending Hill’s® Prescription Diet® c/d® Multicare Feline pet food
- Encourage water intake (i.e. canned food)
- At appropriate intervals, verify dietary compliance, perform complete UA and consider survey radiography or ultrasonography
- Contact VCS for nutritional recommendation for obese or obese-prone cats or cats with concurrent renal disease
AMMONIUM URATE

CRYSTAL IDENTIFICATION

- Urate crystals (ammonium, sodium, potassium, magnesium or calcium) are spherical and often tan in color
- Naturally-occurring uric acid crystals are uncommon

UROLITH IDENTIFICATION

- Characteristically smooth surface with concentric layers of mineral; the outer layers may break off
- Radiolucent or poorly radiopaque
- Stone appearance may vary; quantitative analysis needed to identify urolith(s)

AT-RISK PROFILE

- Low-water intake
- Typically ammonium urate forms in acid to neutral urine
- Portovascular anomalies

INITIAL MANAGEMENT

- Consider surgical removal of stones (voiding urohydropropulsion or lithotripsy in female cats)
- Submit uroliths for quantitative analysis to confirm stone type
- Perform fasting serum chemistry panel and hepatic function tests (i.e. provocative bile acids)
- Provide appropriate treatment for those cats with portovascular anomalies
- Appropriate antibacterial therapy only if urinary tract infection (UTI) present
- Then proceed to long-term management

LONG-TERM MANAGEMENT

- Recommend a low-purine food (consider Hill's® Prescription Diet® l/d® Feline or k/d® Feline pet foods)
- Encourage water intake (i.e. canned food)
- Goal is to achieve USG <1.030
- At appropriate intervals, verify dietary compliance and check urinalysis
GENERAL

OTHER CRYSTALS THAT MAY BE SEEN

Calcium Phosphate (amorphous calcium phosphate surrounding two large struvite crystals)

Bilirubin

Sulfa Drugs

Beware of artifacts, such as microscope slide chips
Diagnosis and Management of Feline Lower Urinary Tract Disease (FLUTD)

Cat presents with signs of LUTD
- Obtain history
- Perform physical exam, complete urinalysis and fasting serum chemistry panel
- If UTI, obtain urine culture and bacterial susceptibility (MIC if possible)
- Perform radiography and contrast studies
- Encourage water consumption (i.e. canned food)

Does the cat have urolith(s), urethral plug, or clinically significant crystalluria?

No
- Confirmed or suspected UTI: treat with appropriate antimicrobials
  If no UTI, cat may have feline idiopathic cystitis (FIC)
  - Consider feeding c/d Multicare Feline pet food
  - Encourage water consumption (i.e. canned food)
  - Recheck and perform complete urinalysis after 2-4 weeks (Target urine pH 6.0-6.5)
  - Recheck and perform complete urinalysis at appropriate intervals

Yes
- Is urolith/urethral plug likely struvite?

No
- Relieve urethral obstruction and correct post renal azotemia if present
- Treat confirmed UTI
- Remove stones by surgery (consider voiding urohydropropulsion or lithotripsy in female cats)
- Perform immediate post-removal radiography
- Submit urolith(s) for quantitative analysis
- Consider feeding Hill's Prescription Diet c/d Multicare Feline pet food and encourage water intake

Yes
- Consult Dissolution Protocol for Feline Struvite Urolithiasis
  Stone identified as ammonium urate:
  Consult feline ammonium urate flowchart
  • Relieve urethral obstruction and correct post renal azotemia if present
  • Treat confirmed UTI
  • Remove stones by surgery (consider voiding urohydropropulsion or lithotripsy in female cats)
  • Perform immediate post-removal radiography
  • Submit urolith(s) for quantitative analysis
  • Consider feeding Hill's Prescription Diet c/d Multicare Feline pet food and encourage water intake

Results of quantitative stone analysis and presence or absence of concurrent disease will dictate the proper Hill's Prescription Diet pet food to feed.

Contact Hill's Veterinary Consultation Service for case consultation

Long-Term Management:
- At appropriate intervals, verify dietary compliance and perform survey radiographs and complete urinalysis
  Target urine pH 6.0-6.5

If average urine pH <6.0, consider potassium citrate

If average urine pH >6.5, look for UTI and treat if confirmed

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Dissolution Protocol for Feline Struvite Urolithiasis

Healthy Adult Cats

Cat presents with signs of LUTD
Urolith(s) or urethral plug detected
Identified as struvite

Feed Hill’s® Prescription Diet® s/d® Feline pet food exclusively*
- Discontinue treats and supplements
- Treat confirmed UTI if present
- Encourage water intake (i.e. canned food)³
- Recheck urinalysis¹ after 2 weeks

if average urine ph > 6.5, or if struvite crystalluria and/or clinical signs present:
- Continue s/d® Feline pet food exclusively for two months
- Perform monthly urinalysis¹

Long-term management:
- Consider feeding Hill’s® Prescription Diet® c/d® Multicare Feline pet food (If cat is obese prone, feed Hill’s® Prescription Diet® w/d® Feline pet food³)
- Encourage water intake (i.e. canned food)³
- At appropriate intervals, verify dietary compliance and perform survey radiographs and complete urinalysis¹

Target urine pH 5.9—6.4

If average urine pH < 5.9:
- Monitor for calcium oxalate
- Verify dietary compliance

If average urine pH 5.9—6.4, and asymptomatic cat:
- Continue s/d® Feline pet food
- Verify dietary compliance
- Check for UTI; antimicrobics

Quantitative stone analysis results¹

Urolith(s) identified as struvite, calcium oxalate, or mixed struvite/calcium oxalate

Urolith(s) identified as ammonium urate: See ammonium urate flowchart

Target urine pH 6.0—6.5

If no change in stones after 2 months, probably NOT pure struvite
- Surgically remove urolith(s) and consider biopsy/culture of bladder wall
- Perform immediate post-removal radiography³
- Submit urolith(s) for quantitative stone analysis¹
- Consider feeding Hill’s® Prescription Diet® c/d® Multicare Feline pet food while awaiting results

Target urine pH 5.9—6.4, and asymptomatic cat:
- Continue s/d® Feline pet food exclusively for two months
- Perform monthly urinalysis¹

Urolith(s) vs crystalluria, urethral plug:

struvite urethral plug/crystalluria

- Continue s/d® Feline pet food exclusively for two months
- Perform monthly urinalysis¹
- Monitor dissolution with monthly radiographs³ to check stone size, density and location

struvite urolith(s)

- Continue s/d® Feline pet food exclusively for two months
- Perform monthly urinalysis¹
- Monitor dissolution with monthly radiographs³ to check stone size, density and location

Yes

Are stones dissolving?

No

Continue s/d® Feline pet food exclusively one month beyond apparent dissolution of uroliths on radiograph then proceed to long-term management*

Continued at top of next page

*Hill’s Prescription Diet s/d Feline pet food is not intended for long-term feeding (over six months)
Urolith(s) identified as possible ammonium urate

- Perform complete urinalysis
- Urine culture and bacterial sensitivity (MIC if possible); treat UTI if confirmed
- Radiography (double contrast) or ultrasound
- Perform fasting serum chemistry panel and hepatic function tests (i.e. provocative bile acids)

Are provocative bile acids and/or liver enzymes elevated?

No

- Consider surgical removal of stones (voiding urohydropropulsion or lithotripsy in female cats)
- Follow up with immediate post-removal radiography
- Perform quantitative analysis to confirm stone type
- Consider feeding Hill’s Prescription Diet l/d Feline or k/d Feline pet foods
- Encourage water intake (i.e. canned food)

Yes

- Perform appropriate follow-up diagnostics for suspected portosystemic shunt or other liver disease (liver biopsy/ultrasound/rechecks)

Continued at top of next page

Monitor Progress

- Recheck urinalysis after 2-4 weeks
- Target urine pH 6.4-7.0
- If urine pH consistently <6.4, verify cat is eating l/d Feline or k/d Feline pet food; add potassium citrate

Long-Term Management

At appropriate intervals:

- Verify dietary compliance
- Perform complete UA
- Double contrast radiography or ultrasound
- Follow-up diagnostics for liver disease as needed
1. If possible, urine should be collected by cystocentesis. The urinalysis should be completed as soon as possible following collection so that the sample’s in vitro characteristics are similar to its in vivo characteristics. If the urinalysis cannot be performed within 1 to 2 hours of collection, the urine should be immediately refrigerated then warmed to room temperature prior to analysis. To measure the pH of urine, pH meters are more accurate than reagent strips, and “pocket type” pH meters are widely available.

2. Check kidneys, urinary bladder, ureters, and urethra for stones, especially if calcium oxalate stones are suspected.

3. At one teaching institution, post-removal radiography confirmed the continued presence of uroliths in 14% of dogs and 20% of cats. We recommend immediate post-removal films for all types of stones in both dogs and cats.

4. Veterinary laboratories which perform quantitative stone analysis:

<table>
<thead>
<tr>
<th>University</th>
<th>Laboratory Name</th>
<th>Phone</th>
</tr>
</thead>
<tbody>
<tr>
<td>University of Minnesota</td>
<td>Urinary Stone Analysis Laboratory</td>
<td>612-625-4221</td>
</tr>
<tr>
<td>St. Paul, MN 55108</td>
<td>School of Veterinary Medicine</td>
<td>Fax: 612-624-0751</td>
</tr>
<tr>
<td>cvmm.umn.edu/depts/</td>
<td></td>
<td>Phone: 530-752-3228</td>
</tr>
<tr>
<td>minnesotauroolithcenter/home.html</td>
<td></td>
<td>Fax: 530-752-0414</td>
</tr>
</tbody>
</table>

* University of Minnesota also performs lithotripsy. Contact the Minnesota Urolith Center for information.

5. Suggestions to encourage water intake: feed canned or moist food, distilled or bottled water, running water (ex: pet fountain), and low-salt chicken broth.

6. Increased water intake is very important if feeding foods with increased fiber such as Hill’s Prescription Diet® w/d® pet food. If feeding an increased fiber food, make food changes gradually over a period of 1-2 weeks.

7. Contact Hill’s Veterinary Consultation Service at 1-800-548-8387 or e-mail vet_consult@HillsPet.com.

8. Give potassium citrate to alkalinate urine. Dose for dogs and cats: 50-75 mg/kg BID with food. Adjust dose to achieve desired effect.

9. Dogs with the following risk factors may not be candidates for dietary management with Hill’s® Prescription Diet® s/d® Canine pet food: Hyperlipidemia (a principal risk factor); history of pancreatitis or at risk of pancreatitis; age above 7 years old; obesity; history of consuming high-fat food; concurrent disease, e.g. hypothyroidism, diabetes mellitus, hyperadrenocorticism; administration of certain drugs, e.g. corticosteroids.

10. Dogs only: To monitor urine pH at home, have clients check two urine samples, one before feeding and one 4-6 hours postprandial. Pocket pH meters are widely available and are more accurate than pH paper. Clients can get supplies to measure urine pH from various sources:

<table>
<thead>
<tr>
<th>Source</th>
<th>Contact Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hobby shops</td>
<td>Hydron Lo-Buff</td>
</tr>
<tr>
<td>School supply stores</td>
<td>Micro Essential Laboratory Inc.</td>
</tr>
<tr>
<td>Swimming pool supply companies</td>
<td>4224 Avenue H</td>
</tr>
<tr>
<td>Aquarium supply stores</td>
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<tr>
<td>Pharmacies</td>
<td></td>
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<td>Pharmacies</td>
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</table>

11. For long-term maintenance, use Hill’s Prescription Diet® c/d® Canine pet food in normal weight dogs that have no problems with fat metabolism. For overweight dogs, or dogs with fiber-responsive conditions or hyperlipidemia, use Hill’s Prescription Diet® w/d® Canine pet food.

12. Dogs only: Lithostat (acetohydroxamic acid) is a urease inhibitor and may help decrease urine pH in patients with UTI caused by a urease-producing organism.

Dose per dog: 12.5 mg/kg BID, used in conjunction with appropriate antibiotics. Re-evaluate in 2-3 weeks. For more information, contact Mission Pharmacal at 1-800-531-3333; missionpharmacal.com.

NOTE: Lithostat is intended for use in humans; not approved for use in dogs.

13. Dogs only: Allopurinol: Dose for dogs 5-10 mg/kg BID for dissolution of ammonium urate uroliths. Beware of use in hepatic or primary renal failure, as allopurinol is metabolized to its active form in the liver and excreted via the kidney. Do not feed foods high in purines to patients on allopurinol as xanthine uroliths could result. Maintenance dose of allopurinol if indicated, 5-10 mg/kg once a day.

NOTE: This drug is intended for use in humans; not approved for use in dogs.

14. Dogs only: Hydrochlorothiazide: Dose for dogs: 2 mg/kg every 12 hours to inhibit calcium excretion in urine.

NOTE: Side effects of this diuretic are many and significant. Use only as a last resort. Monitor for hypokalemia and hypercalcemia (found in patients with absorptive (intestinal) hypercalcuria) every 3-6 months. This drug is intended for use in humans; not approved for use in dogs.

Photos courtesy of Dr. Carl A. Osborne, Minnesota Urolith Center, University of Minnesota.