Lilies are commonly found in households in bouquets or as potted plants. Unfortunately, several types of lilies can be deadly to cats. Easter lily (Lilium longiflorum), tiger lily (L. tigrinum), rubrum lily (L. speciosum), stargazer lily (L. auratum), Japanese show lily (L. lancifolium), some species of day lily (Hemerocallis species), and possibly other members of the Lilium species can cause acute renal failure in cats. Between March 1 and April 1, 2002, veterinarians at the ASPCA Animal Poison Control Center (APCC) consulted on approximately 60 cases of cat exposures to various lilies.

The toxic principle of lilies is unknown, and cats are the only species where renal failure has been reported. All parts of the lily plant are considered toxic to cats, and consuming even small amounts can cause severe poisoning. Within only a few hours of ingestion, the cat may vomit, become lethargic, and/or lose its appetite. These nonspecific signs may continue or temporarily resolve but later worsen as kidney damage progresses. Without prompt and proper treatment by a veterinarian, the cat may develop renal failure, secondary to tubular necrosis, within 36–72 hours.

**Diagnosis**

**Historical Information**

**Species Predisposition:** Reported only in cats.

**Age and Gender Predisposition:** No trend reported.

**Breed Predisposition:** No trend reported.

**Owner Observations**

- Presence of lilies in owner’s home.
- Evidence of bite marks on lily plants in home.
- Evidence of lily plant material in cat’s vomitus.
- Nonspecific signs of lethargy, vomiting, and inappetence are seen early.
- Polyuria/polydipsia.

**Other Historical Considerations/Predispositions**

- Seasonal—Easter lilies are more common in March and April.
- Recent exposure to lily plants or floral arrangements.

**Physical Examination Findings**

- Physical examination may be unremarkable with recent exposures.
- Signs of vomiting, anorexia, and lethargy may temporarily resolve.
- Typical signs include:
  - Oliguria/anuria.
  - Dehydration.
  - Lethargy.
  - Vomiting.
  - Anorexia, adipia. (Cats may be completely anorectic/adipic, but some may eat or drink during treatment. One APCC case report involved a cat with a 53 creatinine level that ate and drank some during treatment, and the initial sign reported by the owner was polyuria.)
  - Epithelial casts.

Other clinical signs reported to the APCC include:

- Depression.
- Salivation.
- Isosthenuria.
- Tremors.
- Ataxia.
- Recumbency.
- Tachypnea.
- Seizure.
- Weakness.
- Vocalization.

**Laboratory Findings**

- **Azotemia:** Elevated BUN (>34 mg/dl) and creatinine (>2.2 mg/dl). Creatinine is often disproportionately elevated.
- **Hyperkalemia:** >6.1 mEq/L.
- **Hyperphosphatemia:** >6.1 mg/dl.
- **Epithelial granular casts** may be seen in urine within 12 hours.
- **Isosthenuria:** (specific gravity = 1.008–1.012).
- **Glucosuria** in absence of hyperglycemia.
- **Increased calcium, phosphorus, and potassium levels** have been reported, as has increased creatinine (levels as high as 53 mg/dl have been seen in APCC reports).

**Other Diagnostic Findings (Postmortem)**

- Renal tubular necrosis (Figure 1).
- Renal tubule tissue mineralization.
- Multifocal mineralization of the renal tubules.
- Mineralization of stomach, aorta, and myocardium.
- Fibrinoid necrosis of muscular renal arteries and arterioles.
- Pancreatitis (possibly a complication of dialysis).

**Summary of Diagnostic Criteria**

- **Urinalysis:** Granular casts may suggest that tubular necrosis is present; isosthenuria may indicate
loss of ability to concentrate urine.

- **Radiographs or ultrasound:** Can be used to measure renal size and cortical thickness.
- **Renal biopsy:** Not necessary; could be used to identify condition of basement membrane if other conditions are present.

### Differential Diagnoses

#### Nephrotoxic Antibiotics
- History of accidental ingestion or therapeutic use.
- May see ototoxicity.
- Serum gentamicin or other aminoglycosides.

#### Acute Glomerulonephritis
- Deposition of immune complexes in renal glomeruli.
- Proteinuria and hematuria present.

#### Acute Decompensation of Chronic Renal Failure
- Renal histopathology lesions confirm chronicity.
- History of renal disease, long-term polydipsia/polyuria.
- Patient will be in poor body condition (underweight, dull hair coat, dehydration).
- Presence of anemia.

#### Interstitial Nephritis
Renal histopathology reveals edema and inflammatory infiltration in addition to tubular damage.

#### Ethylene Glycol Intoxication
- Increased osmolal gap (>20 mOsm/kg).
- Decreased blood pH.
- Increased anionic gap (>25 mEq/L).
- Ethylene glycol in serum or urine.
- Hypocalcemia.
- Presence of early phase of ataxia (1–3 hours postingestion).
- ± Calcium oxalate crystalluria.
- Fluorescence of urine or vomitus when using a Wood’s lamp.

#### NSAID Overdose
- History of exposure.
- Presence of gastrointestinal (GI) effects: Vomiting ± blood, diarrhea, melena, and anorexia.
- Identification of NSAID in serum or tissues (not widely available).

### Cholecalciferol/Vitamin D<sub>3</sub> Derivatives
- Hypercalcemia.
- Rise in calcium/phosphorus precedes azotemia.
- Presence of increased serum 25-hydroxycholecalciferol.
- Kidney, heart, GI may show necrosis and mineralization.

#### Oxalic Acid Ingestion
- History of exposure to anti-rust compounds or cleaning products.
- Oxalic acid can be measured in the urine by colorimetry.

### Heavy Metal Intoxication
- Heavy metal screen:
  - Lead: Whole blood, heparinized or EDTA.
  - Arsenic: Urine (24-hour collection).
  - Mercury: Urine (24-hour collection).
  - Cadmium: Whole blood for acute exposures, urine for chronic exposures.
  - Zinc: Serum or urine.
- Radiographic presence of metallic objects.

### TREATMENT RECOMMENDATIONS

#### Initial Treatment

**Recent Exposures**

According to APCC records, cats that are decontaminated and diuresed soon after early ingestion have a good chance of recovery.

**Early Decontamination**

The most important step is removal of plant material from the GI tract followed by diuresis. Delay in treatment for over 18 hours may result in renal failure.

**Emesis**—3% hydrogen peroxide (1 teaspoon/5 lb PO) or apomorphine (conjunctivally or 0.04 mg/kg IV). Vomiting can be induced in asymptomatic cats with recent exposures (2–3 hours) using apomorphine or hydrogen peroxide. Induction of vomiting is contraindicated in cats with cardiovascular disease, epilepsy, or debilitation, or those in which vomiting has already occurred.

**Activated charcoal** may be helpful in adsorbing the toxic agent in lilies. One to two repeated doses of activated charcoal (1–3 g/kg q4–6h PO) are recommended.

**A cathartic** should be used with first dose of activated charcoal unless the animal is dehydrated or has diarrhea. Sorbitol has been added to some premixed solutions of activated charcoal; if not, 70% at 3 cc/kg PO should be added to the activated charcoal.

**Enemas** may also be helpful in evacuating the intestinal tract. Premixed enema solutions for humans are contraindicated in small animals due to potential electrolyte/acid-base imbalance. General technique is to use plain or soapy warm water.

Once the GI tract has been evacuated, the patient should be placed on diuresis of lactated Ringer’s solution (or normal saline if hyperkalemia is present) at twice the maintenance rate (130 ml/kg/d) for a minimum of 48 hr. During this time, electrolytes, acid base balance, urine specific gravity, and renal values should be monitored closely.

#### Azotemic Cats

Sadly, due to the fact that many cat
owners are unaware of the dangers of lilies, many lily poisonings may not be diagnosed soon after ingestion. Even with a positive diagnosis, no specific antidote is known. Therapy to treat renal failure is symptomatic. Tubular epithelial cells may regenerate with aggressive fluid therapy as long as the basement membrane remains intact; however, anuric cats have a poorer prognosis and may require peritoneal dialysis.

The main goal of treatment with azotemic cats is to prevent further injury to the kidney and maintain fluid, electrolyte, and acid-base balance. As with all acute renal failure patients, meticulous care must be paid to fluid therapy. It is important to monitor urine output. A fluid plan should be devised to correct volume deficits, provide for maintenance needs if the cat is not eating and drinking, and provide for ongoing losses. Careful evaluation of the electrolyte and acid-base status will guide you as to the type or types of fluids needed. Initially monitor body weight (4–6 times/day) and urine production in addition to the electrolyte values and make appropriate adjustments in fluid therapy.

In the author’s opinion, if oliguria (urine flow <2 ml/kg/hr) is present, an effort should be made to increase urine output:

- Furosemide (2 mg/kg slow IV). If no diuresis within 1 hour, repeat furosemide at 4 mg/kg slow IV; if no response within 1 hour, give another dose at 6 mg/kg slow IV.
- An alternative method is to administer furosemide via constant rate infusion (1 mg/kg/hr). If there is no response, discontinue treatment.
- Oliguric patients with hyperkalemia or acidosis may require dialysis.

Dopamine, a selective renal vasodilator, has been previously recommended to increase urine output, but recent literature suggests that it has little benefit in cats since dopamine receptors responsible for diuresis in other species (D1 and D2) are not present in the cat kidney; thus dopamine is no longer recommended. Complications that develop are potentially life threatening and should be treated in an appropriate and timely manner:

- Administration of potassium-free fluids and initiation of diuresis may correct mild to moderate hyperkalemia.
- Bicarbonate (0.5–2 mEq/kg) administered as a slow IV injection may be required to treat moderate hyperkalemia by facilitating an intracellular shift of potassium.
- Sodium bicarbonate is also helpful in treating metabolic acidosis.
- Alternative treatment for hyperkalemia includes glucose (1–2 ml/kg 50% dextrose diluted to 25% IV).

Alternative/Optional Treatments/Therapy

- Peritoneal dialysis. $$\text{-----}$$
- Hemodialysis. $$\text{-----}$$
- Renal transplant. $$\text{-----}$$

Supportive Treatment $$\text{-----}$$

Appropriate nutritional support is critical. Sufficient protein and caloric intake is crucial. A reduced-protein diet may help minimize uremia. A diet providing 2.9–3.0 g protein/kg/day and 70–110 kcal/kg/day is recommended. If vomiting is persistent, partial parenteral nutrition or total parenteral nutrition should be considered. Additional supportive care may also be needed:

- Metoclopramide: (0.2–0.5 mg/kg PO or SQ q8h) for vomiting.
- H₂-receptor blockers to decrease gastric acidity: Ranitidine, 1–2 mg/kg bid IV or SQ, or famotidine, 0.5–1 mg/kg sid IV or SQ.
- Phosphate-binding agents: Aluminum hydroxide (30–90 mg/kg/day initially PO) for hyperphosphatemia.
- Butorphanol: 0.1 mg/kg IV or 0.4 mg/kg SQ.

Patient Monitoring

- Intravascular volume overload may lead to respiratory failure from pulmonary edema.
- BUN.
- Creatinine.
- Calcium.
- Phosphorus.
- Potassium.
- Acid–base balance.

Home Management

- Provide adequate nutrition.
- Maintain hydration.
- Monitor urine output, appetite, and overall disposition.

Milestones/Recovery Timeframes

- 48-hour diuresis without elevations in BUN/creatinine can decrease fluid administration. Watch for lowering of BUN and creatinine.
- Tubular regeneration may begin...
as early as 5 days but could take several weeks for the regenerated tubules to become completely functional.

Treatment
Contraindications
- Contraindications for using furosemide include anuria and serious electrolyte depletion.
- Avoid potassium-containing fluids in cases of hyperkalemia.
- Use care when administering drugs that require renal excretion.

PROGNOSIS
Tubular epithelial cells may regenerate with aggressive fluid therapy as long as the basement membrane remains intact; however, anuric cats have a poorer prognosis and may require peritoneal dialysis. Tubular regeneration and intact tubular basement membranes indicate reversibility is possible. Possibility of long-term renal injury requiring lifetime home management.

Favorable Criteria
- Ability to produce urine.
- Ability to concentrate urine.
- Decreasing renal values (BUN and creatinine).
- Maintenance of appetite.

Unfavorable Criteria
- Anuria.
- Isosthenuria.
- Increasing renal values (BUN and creatinine).
- Anorexia.

ON THE NEWS FRONT
The ASPCA Animal Poison Control Center, in partnership with the Cat Fanciers’ Association, is leading a nationwide campaign about the dangers of lilies. Online materials, including photos of common types of dangerous lilies and a list of nontoxic plants, can be downloaded at www.cfainc.org/articles/lilies.html.

RESOURCE LIST
- Metoclopramide (Reglan®, Wyeth)—0.2–0.5 mg/kg PO or SQ q8h as needed for vomiting.
- Ranitidine (Zantac®, Pfizer)—1–2 mg/kg bid IV or SQ to decrease gastric acidity.
- Famotidine (Pepcid®, Merck)—0.5–1 mg/kg sid IV or SQ to decrease gastric acidity.
- Aluminum hydroxide (Amphojel®, Wyeth)—30–90 mg/kg/day initially for hyperphosphatemia.
- Butorphanol (Torbutrol®, Fort Dodge Animal Health)—0.1 mg/kg IV or 0.4 mg/kg SQ for analgesia.
- Furosemide (Lasix®, Intervet)—Indicated for oliguria. Start with 2 mg/kg slow IV. If no diuresis within 1 hour, repeat at 4 mg/kg slow IV. If no response within 1 hour, repeat at 6 mg/kg slow IV.

RECOMMENDED READING