

Nephrotoxicosis in a cat following ingestion of Asiatic hybrid lily (*Lilium* sp.)

Mark A. Brady, Evan B. Janovitz

A 1-year-old, 4.3-kg, neutered-male, domestic shorthair cat was admitted to a veterinary specialty practice for lethargy, anorexia, and vomiting. The owner reported that the cat had ingested leaves of an Asiatic hybrid lily (*Lilium* sp.) on 3 consecutive days beginning 6 days prior to admission (Fig. 1). One day prior to admission, the cat exhibited polyuria and polydipsia and vomited sporadically. At admission, the cat was anuric and vomited frequently. The cat was estimated to be 7% dehydrated by physical examination and was essentially comatose, being unresponsive to external stimuli. Rectal temperature was 37 C, heart rate was 160 per minute, and respiratory rate was 30 per minute.

Abnormalities detected by serum biochemical analysis^a were azotemia (serum urea nitrogen > 130 mg/dl, reference range = 14-36 mg/dl; creatinine > 13.6 mg/dl, reference range = 0.8-2.4 mg/dl), hyperphosphatemia (>16.1 mg/dl, reference range = 2.5-5.5 mg/dl), hyperkalemia (7.0 mmol/liter, reference range = 3.7-5.8 mmol/liter), hyponatremia (138 mmol/liter, reference range = 150-165 mmol/liter), and hypochloridemia (100 mmol/liter, reference range = 112-129 mmol/liter). The hematocrit (43%), plasma protein concentration (7.2 g/dl, as measured by refractometry), and serum calcium concentration (10.1 mg/dl) were within normal limits.

Urine obtained by cystocentesis was light yellow and cloudy. Abnormalities detected by urinalysis were isosthenuria (specific gravity = 1.014), cylindruria (20-25 granular casts per low-magnification field in sediment), mild glucosuria (1+ on urine dipstick), proteinuria (4+ on urine dipstick), and moderate amounts of nonhemolyzed blood. Low numbers of erythrocytes and leukocytes were also observed in the urine sediment.

The combination of azotemia, hyperphosphatemia, isosthenuria, and cylindruria indicated primary renal failure with tubular damage.¹ The history, clinical signs, and laboratory data supported a diagnosis of primary renal failure secondary to the ingestion of *Lilium* sp.² (Carson T, Sanderson T, Halbur P: 1994, Acute nephrotoxicosis in cats following ingestion of lily (*Lilium* sp.). Proc Annu Meet Am Assoc Vet Lab Diag 37:43 [abstr.]; Hall JO: 1992, Nephrotoxicity of Easter lily (*Lilium longiflorum*) when ingested by the cat. Proc Am Coll Vet Intern Med Forum 6:121 [abstr. 49]; Hovda L: 1995, Plants toxic to dogs and cats. Proc Am Coll Vet Intern Med Forum 13:617-619 [abstr.]). Given the poor prognosis, the owners elected euthanasia, and because they wanted their cat returned for burial, they only permitted re-

moval of one kidney. The left kidney was collected immediately after euthanasia, placed in 10% formalin, and routinely processed for histopathology.

Microscopic examination of an HE-stained section of this kidney revealed acute tubular necrosis, consistent with nephrotoxicosis. The epithelium of most tubules had undergone varying degrees of degeneration and necrosis (Fig. 2). Although lesions were diffuse, cortical tubules were more severely affected than medullary tubules, and proximal convoluted tubules were more severely affected than straight tubules, thin segments, or ducts. Degenerate epithelial cells had swollen, irregularly vacuolated cytoplasm. Necrotic epithelial cells had granular eosinophilic cytoplasm and either lacked a nucleus or exhibited pyknosis and karyorrhexis. Several tubules were lined by flattened epithelium or were devoid of epithelium. The lumens of many tubules and ducts contained eosinophilic, granular remnants of desquamated, necrotic epithelial cells, granular casts, or homogeneously eosinophilic material (hyaline casts). Nuclear debris was admixed with granular casts in some tubules. Within a few tubules were partially calcified casts and debris and widely scattered, amorphous birefringent crystals. Epithelial cells lining portions of some tubules, especially those of straight tubules in medullary rays, were hypertrophic with vesicular nuclei, and several were in mitosis. The tunica media of most muscular arteries, especially the arcuate arteries, had undergone varying degrees of acute fibrinoid necrosis characterized by disruption of myocytes, deposition of flocculent eosinophilic material, and the presence of scattered pyknotic debris. Most veins were dilated. Low numbers of lymphocytes had accumulated in the interstitium around some cortical veins and in connective tissue adjacent to the renal pelvis.

Microscopic lesions in the kidney were compatible with nephrotoxic tubular necrosis of a few days duration.⁵ This interpretation was based on the selective damage to renal tubular epithelium with maintenance of tubular basement membranes and evidence of epithelial regeneration. Vacuolation of intact tubular epithelial cells probably represented lipid accumulation, a morphologic feature of normal feline renal tubular epithelium, in addition to hydropic degeneration.⁵ Nephrotoxic tubular necrosis is not a specific diagnosis and can result from a variety of nephrotoxins, such as aminoglycoside antibiotics (e.g., gentamicin), metals (e.g., lead, arsenic, mercury), or metabolites of ethylene glycol.⁵ In this case, the Asiatic hybrid lily was the probable source of the nephrotoxin. The birefringent crystals may have been oxalates, but because they were present in such low numbers, they were unlikely to have caused tubular obstruction. Intratubular deposition of oxalates can result from reduced excretion of endogenous oxalates that occurs with either acute or chronic renal failure.³ Since the number of crystals deposited in this cat's kidney was small and lily plants have not been reported to contain oxalates, oxalate crystal depo-

From Michigan Veterinary Specialists (Brady), 21600 West 11 Mile Road, Southfield, MI 48076, and the Animal Disease Diagnostic Laboratory and Department of Veterinary Pathobiology (Janovitz), Purdue University, West Lafayette, IN 47907. Current address (Brady): Veterinary Internal Medicine Specialists of Kansas City, Inc., 10333 Metacalf Avenue, Overland Park, KS 66212.

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Figure 1. Photograph of a blooming Asiatic hybrid lily similar to that ingested by the cat with nephrotoxicosis as described in this case.

sition was probably secondary to reduced renal function with accumulation of endogenous oxalates. Since fibrinoid degeneration of muscular arteries was peracute (i.e., not associated with inflammatory cell infiltration, hypertrophy of smooth muscle cells, nor fibroplasia), it was probably secondary to uremia.^{4,6} In this case, mild lymphocytic interstitial inflammation, a relatively chronic lesion, was unlikely to have caused or resulted from acute tubular necrosis.

At least 16 cases of nephrotoxicosis associated with ingestion of Asiatic lily species and their hybrids, *Lilium* spp., by cats have been reported² (Carson T, Sanderson T, Halbur P: 1994, Acute nephrotoxicosis in cats following ingestion of lily (*Lilium* sp.). Proc Annu Meet Am Assoc Vet Lab Diag 37:43 [abstr.]; Hall JO: 1992, Nephrotoxicity of Easter lily (*Lilium longiflorum*) when ingested by the cat. Proc Am Coll Vet Intern Med Forum 6(2):121 [abstr. 49]; Hovda L: 1995, Plants toxic to dogs and cats. Proc Am Coll Vet Intern Med Forum 13: 617–619 [abstr.]). Of these, 13 involved the Easter lily (*Lilium longiflorum*), 2 an Asiatic hybrid, and 1 the tiger lily (*Lilium tigrinum*). Easter lily-induced nephrotoxicosis has been recognized since at least 1989 (Carson T, Sanderson T, Halbur P: 1994, Acute nephrotoxicosis in cats following ingestion of lily (*Lilium* sp.). Proc Annu Meet Am Assoc Vet Lab Diag 37:43 [abstr.]; Hall JO: 1992, Nephrotoxicity of Easter lily (*Lilium longiflorum*) when ingested by the cat. Proc Am Coll Vet Intern

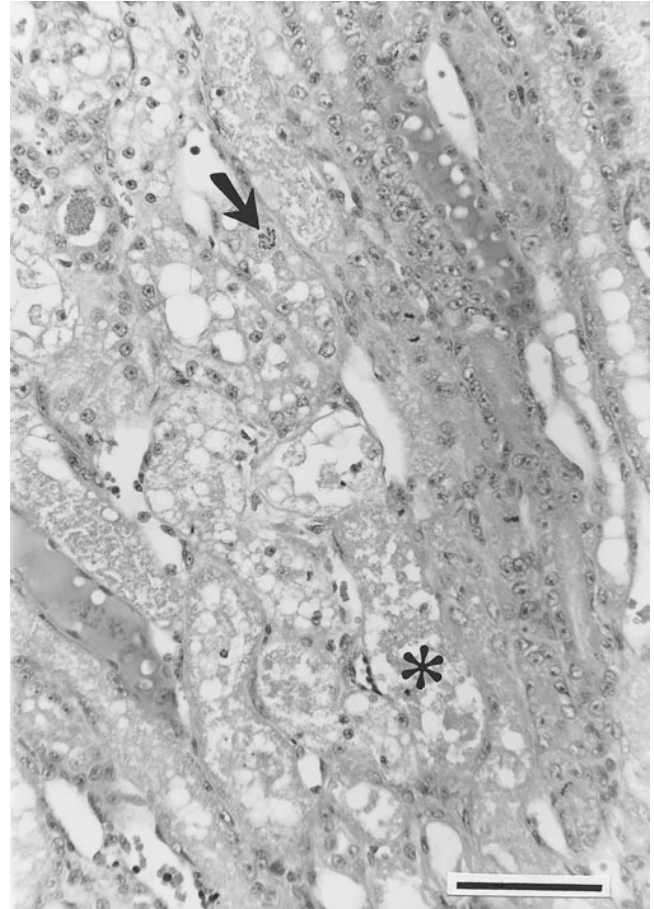


Figure 2. Photomicrograph of a section of renal cortex from a cat with acute nephrotoxicosis following ingestion of Asiatic hybrid lily plant leaves. Several tubules are devoid of epithelium and are filled with granular cellular debris (*). A few tubular epithelial cells are in mitosis (→). HE stain; bar = 100 μ m.

Med Forum 6(2):121 [abstr. 49]). By 1990, 5 cases of renal failure in cats that had ingested Easter lily had been reported to the National Animal Poison Control Center (NAPCC).² These cats died within 5 days of ingestion. Typically, intoxicated cats began vomiting 6–12 hours after ingestion, perhaps as a result of gastric irritation.² Vomiting then subsides until renal failure ensues 24–72 hours after ingestion, when isosthenuria, proteinuria, glucosuria, and cylindruria are evident.² In those cases for which histopathology was performed, kidneys revealed extensive tubular necrosis (Carson T, Sanderson T, Halbur P: 1994, Acute nephrotoxicosis in cats following ingestion of lily (*Lilium* sp.). Proc Annu Meet Am Assoc Vet Lab Diag 37:43 [abstr.]).

The parent compound(s) or metabolite(s) derived from Easter lily plants that induce nephrotoxic tubular necrosis is (are) presently unknown. Therefore, treatment is not specific but rather is directed at minimizing further absorption of plant-derived compounds from the gastrointestinal tract and managing acute renal failure.² Regimens include induction of emesis, gavage with activated charcoal and saline cathartics, and administration of intravenous fluids to promote diuresis. Four of 8 cats (50%) that were treated after they had

ingested Easter lily survived (Hall JO: 1992, Nephrotoxicity of Easter lily (*Lilium longiflorum*) when ingested by the cat. Proc Am Coll Vet Intern Med Forum 6(2):121 [abstr. 49]). The 4 surviving cats were treated within 6 hours after plant ingestion and before renal failure had ensued. Treatment of the 4 cats that eventually died with renal failure was delayed for greater than 18 hours after plant ingestion.

This case provides further documentation for cat owners, veterinarians, and veterinary diagnosticians that Asiatic lilies, including hybrid varieties, are nephrotoxic for cats. Renal failure secondary to renal tubular necrosis ensues 1–3 days after ingestion. Preventing further plant digestion and inducing diuresis within a few hours after plant ingestion provide the best chance of survival.

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Sources and manufacturers

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Bovine viral diarrhea virus in New World camelids

Ellen B. Belknap, James K. Collins, R. Scott Larsen, Kevin P. Conrad

Abstract. A virus known to cause multiple problems in cattle, bovine viral diarrhea virus, was isolated from 3 different cases in New World camelids. Virus isolation, immunoperoxidase staining, and fluorescent antibody staining were used to detect the virus. The herds involved were screened for antibody titers to bovine viral diarrhea and virus isolation from the buffy coat. Bovine viral diarrhea virus should be considered as a cause of death in young and old New World camelids.

Bovine viral diarrhea virus (BVDV) is a small, enveloped, positive-stranded RNA virus classified in the family Flaviviridae as a pestivirus along with hog cholera virus of swine and border disease of sheep.⁵ Many strains of BVDV exist and, based on sequence homology, BVDV can be further classified as either genotype I or II. Two biotypes of BVDV exist based on the cytopathogenicity in cell culture: cytopathic and noncytopathic BVDV. Infection of cattle with either viral biotype or simultaneous infection of cattle with both biotypes may induce a variety of clinical presentations affecting multiple organ systems.¹ Clinical disease ranges from the more common subclinical infections to the fatal form known as mucosal disease. In immunocompetent animals, clinical signs may include diarrhea, oral ulcerations, and depression. In pregnant immunocompetent animals, infertility, abortions, and congenital defects may be observed.

While normally a pathogen of cattle, BVDV has been isolated from goats, captive and free-living ruminants, a camel, and pigs.^{2,7,10} Antibody titers to BVDV have been detected in New World camelids (NWC) housed with persistently infected cattle and following a BVDV abortion episode in pygmy goats.^{8,9} While there is mention of isolations of BVDV from llamas associated with abortion, excessive nasal discharge, or diarrhea,^{3,8,10} there are no reports of clinical cases in NWC or herd BVDV status.

A 13-year-old, 524-pound pregnant llama was admitted for an elective cesarean section due to physical constraints relative to excessive fat deposits within the pelvic canal. The llama had delivered 9 previous crias and was 338 days in gestation with the current pregnancy. The immediately preceding pregnancy had resulted in delivery of a dead fetus. Dexamethasone (10 mg IM) was administered 24 hours prior to the planned surgery to enhance pulmonary maturation of the fetus. Due to the dam's excessive body condition, ultrasound of the fetus was not possible. At surgery, the male cria was stillborn, the hair epilated easily, and the corneas were cloudy. Gross necropsy of the cria revealed no other abnormalities. Fluorescent antibody (FA) testing for BVDV (Table 1), equine herpesvirus-1 (EHV-1), chlamydia, and bovine herpesvirus-1 (BHV-1) was negative, and

From the Departments of Clinical Sciences (Belknap, Larsen) and Microbiology (Collins), College of Veterinary Medicine and Biomedical Sciences, Colorado State University, Fort Collins, CO 80523, and the Woodland Veterinary Clinic (Conrad), Woodland Park, CO 80886.

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