

Use of a nitinol gooseneck snare catheter for removal of adult *Dirofilaria immitis* in two cats

Merrilee T. Small, DVM; Clarke E. Atkins, DVM, DACVIM; Sonya G. Gordon, DVM, DACVIM; Adam J. Birkenheuer, DVM, PhD, DACVIM; Margaret A. Booth-Sayer, DVM; Bruce W. Keene, DVM, MS, DACVIM; Yoko Fujii, DVM, PhD; Matthew W. Miller, DVM, MS, DACVIM

Case Description—2 cats were examined because of congestive heart failure secondary to heartworm infection.

Clinical Findings—One cat had severe abdominal distention and the other had dyspnea secondary to chylothorax. Both had loud right-sided heart murmurs, precordial thrills, and jugular distension. Thoracic radiography revealed cardiomegaly and enlarged caudal pulmonary arteries. Echocardiography revealed tricuspid regurgitation and multiple hyperechoic structures consistent with adult *Dirofilaria immitis* within the right atrium, right ventricle, and main pulmonary artery. Pulmonary hypertension was documented by means of Doppler echocardiography in 1 cat.

Treatment and Outcome—Cats were anesthetized, and a nitinol gooseneck snare catheter was introduced into the right side of the heart via a jugular venotomy. In the first cat, the snare was used to retrieve 5 female and 2 male adult *D immitis*. The catheter was then passed into the main pulmonary artery in an unsuccessful attempt to retrieve remaining heartworms. In the second cat, 2 adult female *D immitis* were removed from the right atrium with the nitinol snare. In both cats, clinical signs resolved within 4 weeks after the procedure.

Clinical Relevance—Findings suggested that use of a nitinol gooseneck snare catheter may be a safe and effective technique for removing adult *D immitis* from the right atrium and ventricle in cats and that successful removal of adult heartworms in infected cats may resolve clinical signs of right-sided congestive heart failure and chylothorax. In addition, findings in 1 cat suggested that removal of all adult heartworms may not be necessary for clinical signs to resolve. (*J Am Vet Med Assoc* 2008;233:1441–1445)

A 10-year-old castrated male domestic shorthair cat was referred to the Texas Veterinary Medical Center at Texas A&M University for evaluation and possible treatment of heartworm disease. The cat had been examined by the referring veterinarian 1 week previously because of progressive abdominal distension of approximately 1 month's duration. Echocardiography at that time revealed multiple echogenic structures characteristic of adult *Dirofilaria immitis* within the right atrium and ventricle, and the cat was treated with furosemide and enrofloxacin. According to the owner, the cat had access to the outdoors and had not been receiving heartworm prophylaxis.

On initial examination at the Texas Veterinary Medical Center, the cat was bright, alert, and responsive, but was thin (body weight, 4.54 kg [10 lb]). Severe distension of the abdomen with a palpable fluid wave and severe jugular distention were evident. The cat appeared adequately hydrated, mucous membranes were pink, and capillary refill time was < 2 seconds. Respiratory rate was 50 breaths/min, and no abnormalities were detected during auscultation of the lungs. Heart rate was 188 beats/min, and a grade V/VI holosystolic heart murmur, loudest over the area of the cardiac apex on the right side of the thorax, was audible during cardiac auscultation. Treatment with furosemide and enrofloxacin was discontinued.

Echocardiography revealed multiple linear, mobile, parallel-walled hyperechoic structures consistent with adult *D immitis* within the right atrium, right ventricle, and main pulmonary artery. Severe tricuspid insufficiency was present secondary to worms within the tricuspid valve orifice. However, artifacts associated with the hyperechoic worms made Doppler evaluation of the tricuspid regurgitation impossible. Thoracic radiography revealed a globoid cardiac silhouette, large caudal pulmonary lobar and intralobar arteries (right larger than left), distention of the caudal vena cava, and a reduction in detail within the cranial portion of the abdomen.

From the Department of Clinical Sciences, College of Veterinary Medicine, North Carolina State University, Raleigh, NC 27606 (Small, Atkins, Birkenheuer, Booth-Sayer, Keene, Fujii); and the Department of Small Animal Clinical Sciences, College of Veterinary Medicine and Biomedical Sciences, Texas A&M University, College Station, TX 77843 (Gordon, Miller). Dr. Small's present address is Tidewater Veterinary Cardiology, 364 S Independence Blvd, Virginia Beach, VA 23452. Dr. Booth-Sayer's present address is Carolina Veterinary Specialists Medical Center, 2225 Township Rd, Charlotte, NC 28273. Dr. Fujii's present address is Department of Surgery, Azabu University, 1-17-71 Fuchinobe, Sagami-hara-shi, Kanagawaken, Japan. The authors thank Anne Meyers, Petra Guity, and Kathy Glaze for technical assistance. Address correspondence to Dr. Atkins.

A CBC and serum biochemical profile were performed. Hematologic abnormalities included anemia (PCV, 21.6% [reference range, 29% to 48%]; RBC count, $4.07 \times 10^6/\mu\text{L}$ [reference range, 5.92 to $9.93 \times 10^6/\mu\text{L}$]) and anisocytosis. Serum biochemical abnormalities included mild azotemia (SUN, 40 mg/dL; reference range, 19 to 33 mg/dL), hyperglycemia (140 mg/dL; reference range, 65 to 131 mg/dL), hyperglobulinemia (4.3 g/dL; reference range, 2.3 to 3.8 g/dL), and high alanine aminotransferase activity (191 U/L; reference range, 26 to 84 U/L). A urinalysis was not performed at the time of hospital admission because the severe ascites precluded use of cystocentesis for collection of a urine sample. Heartworm testing was also not performed.

The cat was premedicated with glycopyrrolate (0.01 mg/kg [0.0045 mg/lb], IM), butorphanol (0.2 mg/kg [0.09 mg/lb], IM), and methylprednisolone sodium succinate (10 mg/kg [4.5 mg/lb], IV), and anesthesia was induced with diazepam (0.2 mg/kg, IV) and etomidate (0.2 mg/kg, IV). An endotracheal tube was placed, and anesthesia was maintained with isoflurane. A ventilator was connected to the anesthetic circuit to allow for intermittent positive-pressure ventilation.

The cat was positioned in left lateral recumbency, and the right side of the cervical region was surgically prepared. The right jugular vein was isolated, a venotomy was performed, and a 4-F catheter (102 cm in length) containing a nitinol gooseneck snare (4 mm in diameter and 120 cm in length with a 10-mm-diameter snare)^a was introduced and advanced into the right atrium under fluoroscopic and transesophageal echocardiographic guidance (Figure 1). The snare was deployed within the right atrium and right ventricle several times and gently retracted each time. Five female and 2 male heartworms were retrieved through the jugular venotomy. The catheter was then passed into the main pulmonary artery in an attempt to retrieve additional heartworms. However, ventricular tachycardia

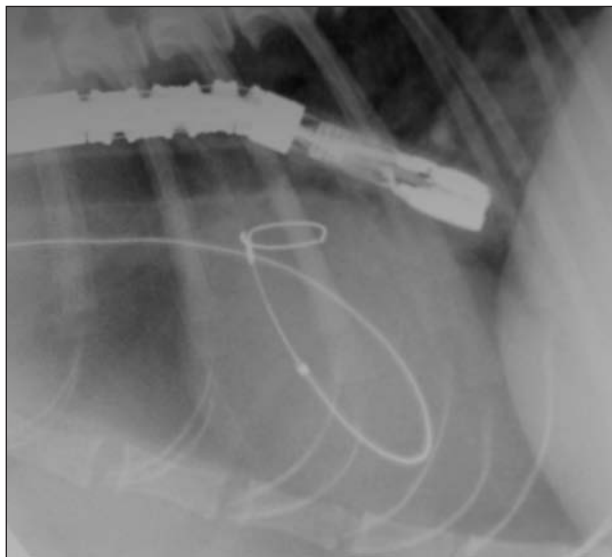


Figure 1—Fluoroscopic image of the thorax of a cat in which a nitinol gooseneck snare was used for removal of adult heartworms. The snare was introduced through a right jugular venotomy and advanced into the main pulmonary artery. A transesophageal ultrasound probe can also be seen.

developed. Therefore, the catheter was retracted, and lidocaine (0.88 mg/kg [0.4 mg/kg], IV) and methylprednisolone (5 mg/kg [2.3 mg/lb], IV) were administered. No further attempts were made to retrieve remaining heartworms. The right jugular vein was ligated proximal and distal to the venotomy site with 2-0 silk, and the skin was closed routinely.

The cat recovered from anesthesia without complications. Packed cell volume, measured after the cat had recovered, was 16%. Anemia was attributed to IV fluid therapy and blood loss during the heartworm extraction procedure.

The cat was admitted to the intensive care unit after the procedure. Fluids (lactated Ringer's solution plus 30 mEq KCl/L at 3.3 mL/kg/h [1.5 mL/lb/h]) were administered IV for 18 hours following the procedure. The cat was placed in a cage with an oxygen-enriched atmosphere with approximately 40% inspired oxygen.^b Abdominocentesis was performed, and 340 mL of straw-colored fluid was obtained. Analysis of the fluid indicated that it was a modified transudate (total protein concentration, 3.7 g/dL; nucleated cell count, 502 cells/ μL ; differential cell count, 75% nondegenerate neutrophils, 17% lymphocytes, 7% large mononuclear cells, and 1% eosinophils). Analysis of a urine sample obtained by means of cystocentesis following abdominocentesis revealed isosthenuria (specific gravity, 1.017). Dipstick^c analysis of the urine sample revealed proteinuria, and cytologic analysis revealed hematuria (1 to 3 RBC/hpf) and bacteriuria (few bacteria/hpf).

The following morning, a grade V/VI holosystolic murmur was still audible. Echocardiography revealed at least 1 adult heartworm within the pulmonary trunk, although none were identified in the right atrium or right ventricle. Intravenous fluid therapy was discontinued, and treatment with prednisone (1 mg/kg, PO, q 24 h) was begun. On the second day after surgery, abdominocentesis was repeated because of ongoing abdominal distension; 275 mL of fluid was removed. Furosemide (1.3 mg/kg [0.59 mg/lb], PO, q 24 h) and spironolactone (0.5 mg/kg, PO, q 24 h) were added to the treatment regimen. The dosage of furosemide was subsequently reduced to 0.625 mg/kg (0.28 mg/lb), PO, every 24 hours, and amoxicillin-clavulanic acid (12.5 mg/kg [5.7 mg/lb], PO, q 12 h) was administered because of urinary tract inflammation.

The cat was discharged 2 weeks after surgery. Although some ascitic fluid remained at this time, additional abdominocentesis had not been required. At the time of discharge, the cat was being treated with prednisone (1 mg/kg, PO, q 24 h), furosemide (0.625 mg/kg, PO, q 48 h), spironolactone (0.5 mg/kg, PO, q 48 h), and amoxicillin-clavulanic acid (12.5 mg/kg, PO, q 12 h). Packed cell volume was 26%, plasma total protein concentration was 8.5 g/dL (reference range, 6.1 to 7.7 g/dL), SUN concentration was 59 mg/dL, and serum creatinine concentration was 5.4 mmol/dL (reference range, 0.8 to 1.8 mmol/L).

Three weeks after discharge, the cat appeared healthy, did not have any identifiable ascites, and weighed 3.86 kg (8.5 lb). No heart murmurs were heard during cardiac auscultation, although a single heartworm was still evident within the main pulmonary

artery during echocardiography. The treatment regimen was changed so that only prednisone (0.65 mg/kg [0.29 mg/lb], PO, q 48 h) and spironolactone (0.65 mg/kg, PO, q 48 h) were still being administered. In addition, the owner was instructed to administer ivermectin^d (43 µg/kg [19.7 µg/lb], PO, q 30 d) for heartworm prophylaxis. Treatment with prednisone and spironolactone was discontinued approximately 3 months later.

Two years after surgery, results of a CBC and serum biochemical profile performed by the referring veterinarian were unremarkable. Three years after surgery, the cat was reportedly doing well and was only receiving monthly heartworm prophylaxis. Follow-up echocardiography was not performed.

An approximately 5-year-old spayed female domestic medium-hair cat was referred to the Veterinary Teaching Hospital at North Carolina State University for evaluation and possible treatment of heartworm infection. The cat had initially been examined by the referring veterinarian because of progressive dyspnea of 2 days' duration. The cat resided in the coastal region of North Carolina, and although it had access to the outdoors, there was no history of trauma. Vaccinations were current, and results of tests for FeLV and FIV were negative. The cat was not receiving any heartworm prophylaxis. The referring veterinarian determined that the cat had pleural effusion and removed approximately 100 mL of chylous-appearing effusion. The cat was subsequently referred to a local veterinary specialty hospital, where echocardiography revealed multiple, linear, mobile, parallel-walled hyperechoic structures consistent with adult *D immitis* within the right atrium and right ventricle. Thoracocentesis confirmed the presence of chylothorax, and the cat was found to have normocytic, normochromic anemia (Hct, 27.9%; reference range, 29% to 48%) and eosinophilia (1,099 eosinophils/µL; reference range, 0 to 1,000 eosinophils/µL). A single mast cell was seen during examination of a blood smear. The cat was treated with prednisone (1.2 mg/kg [0.55 mg/lb], PO, q 24 h) and furosemide (1.5 mg/kg [0.68 mg/lb], PO, q 24 h) and referred to the Veterinary Teaching Hospital at North Carolina State University for possible heartworm removal.

On initial examination at the veterinary teaching hospital, the cat was quiet, responsive, and in good body condition (body weight, 3.89 kg [8.6 lb]). The cat was estimated to be 5% to 6% dehydrated, and mucous membranes were pale pink. Respiration was labored and rapid (80 breaths/min). Muffled breath sounds were evident during thoracic auscultation, and percussion of the ventral aspect of the thorax provided a dull sound. The heart rate was 220 beats/min, and a grade V/VI holosystolic murmur, loudest over the area of the cardiac apex on the right side of the thorax, was audible during cardiac auscultation. A palpable thrill was evident in conjunction with the murmur, and the jugular veins were distended and pulsatile. The liver appeared larger than normal during abdominal palpation and was palpable 1 cm beyond the costal arch. Systolic blood pressure, determined by means of Doppler sphygmomanometry, was 170 mm Hg.

Echocardiography revealed substantial pleural effusion, and 155 mL of chylous effusion was subsequently re-

moved by means of thoracocentesis. Multiple hyperechoic linear opacities consistent with adult *D immitis* were evident within the right ventricle and crossing the tricuspid valve into the right atrium. Severe tricuspid insufficiency with subjective right-sided volume overload was evident. Velocity of the tricuspid insufficiency was not measured during the initial echocardiographic examination because of difficulties obtaining an adequate image and a desire to avoid additional stress on the patient. Mild pulmonic insufficiency was also present. The left side of the heart appeared volume deficient, and the interatrial septum was bowed toward the left. Thoracic radiography performed after thoracocentesis revealed moderate cardiomegaly with large caudal lobar pulmonary arteries and probable collapse of the right middle lung lobe.

A CBC and serum biochemical profile were performed. Hematologic abnormalities included mild regenerative anemia (Hct, 27.9%) with moderate anisocytosis and poikilocytosis. Serum bilirubin concentrations were near the upper reference limit, but results of the serum biochemical profile were unremarkable otherwise. Urinalysis revealed substantial microscopic hematuria. Results of heartworm antibody and antigen tests^e were positive.

In preparation for heartworm removal, the cat was premedicated with methylprednisolone sodium succinate (12 mg/kg, IV), cefazolin (20 mg/kg [9.1 mg/lb], IV), diphenhydramine (2 mg/kg, IV), and hydromorphone (0.04 mg/kg [0.018 mg/lb], IV). Anesthesia was induced with isoflurane delivered in an induction chamber. An endotracheal tube was placed, and anesthesia was maintained with isoflurane. A ventilator was connected to the anesthetic circuit to allow for intermittent positive-pressure ventilation.

The cat was positioned in left lateral recumbency, and the right side of the cervical region was surgically prepared. The right jugular vein was isolated, a venotomy was performed, and a 4-F catheter (102 cm in length) containing a nitinol gooseneck snare (4 mm in diameter and 120 cm in length with a 10-mm-diameter snare)^a was introduced and advanced into the right atrium under fluoroscopic guidance. The snare was deployed within the right atrium and gently retracted, along with 2 adult female heartworms (Figure 2). In-

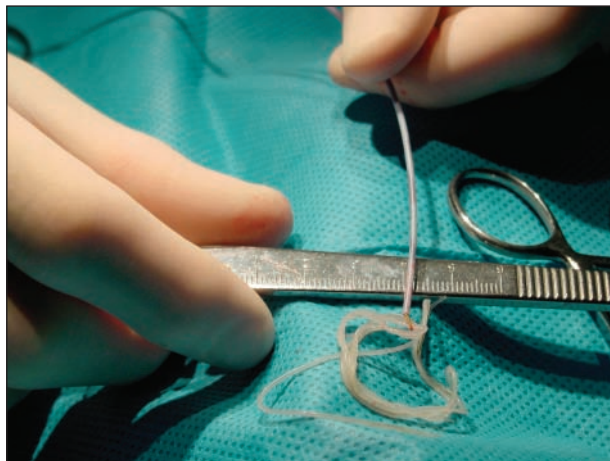


Figure 2—Photograph of 2 adult heartworms removed from a cat with a nitinol gooseneck snare.

traoperative transthoracic echocardiography did not reveal any other heartworms in the heart or pulmonary arteries.

A 4-F side-hole NIH catheter^f was then introduced into the right jugular vein and advanced into the main pulmonary artery, and pulmonary angiography was performed with sodium iohexol^g (266 mg/kg [121 mg/lb], IV). The pulmonary arteries were observed to be tortuous, and a small, nonlinear filling defect was evident in the proximal portion of the left pulmonary artery. The filling defect was assumed to be a pulmonary arterial thrombus. The right jugular vein was ligated proximal and distal to the venotomy site with 2-0 silk, and the skin was closed routinely. The cat recovered from anesthesia without complications.

During a physical examination the following morning, the right-sided thrill had resolved, although a grade III/VI systolic murmur was still present. Follow-up echocardiography revealed a substantial improvement in left ventricular filling and a reduction in size of the right side of the heart. Peak pulmonary arterial systolic pressure, estimated on the basis of velocity of the tricuspid regurgitant jet, was 62 mm Hg, which was considered indicative of pulmonary hypertension. Results of a follow-up heartworm antigen test were negative.

The cat was discharged with instructions that the owners administer prednisone (1.25 mg/kg, PO, q 24 h) and dalteparin^h (100 U/kg [45 U/lb], SC, q 24 h for 1 month), along with ivermectin (43 µg/kg [19.5 µg/lb], PO, q 30 d) for heartworm prophylaxis.

The cat was reexamined at the veterinary teaching hospital 2 weeks after discharge because of recurrent signs of pleural effusion. Respiratory rate was 48 breaths/min, and breath sounds were muffled. Heart rate was 200 beats/min, and a grade II/VI systolic murmur could be heard over an area to the right of the sternum. Thoracocentesis was performed, and 120 mL of chylous effusion was removed. Clinicopathologic testing revealed that the anemia and hemoglobinuria had resolved (Hct, 29.5%). Enalaprilⁱ (0.6 mg/kg [0.27 mg/lb], PO, q 24 h), furosemide (1.5 mg/kg, PO, q 12 h), and quercetin-3-rutinoside^j (65 mg/kg [30 mg/lb], PO, q 8 h) were added to the treatment regimen. The prednisone dosage was tapered over a 1-month period, and administration was eventually discontinued.

The cat was reevaluated 14 weeks after heartworm extraction. Physical examination revealed a slight (0.2 kg [0.44 lb]) weight gain and resolution of the cardiac murmur. Echocardiography revealed mild tricuspid insufficiency with substantial reduction in size and volume of the right side of the heart. Peak pulmonary arterial systolic pressure, estimated on the basis of the tricuspid regurgitant jet, was approximately 30 mm Hg. Administration of furosemide and quercetin-3-rutinoside was discontinued. Administration of enalapril was discontinued 36 weeks after heartworm extraction. The cat was doing well 3.5 years after heartworm extraction.

Discussion

Findings in the present report suggested that use of a nitinol gooseneck snare may be a safe and effective method for removing adult heartworms in infected

cats and that successful removal of adult heartworms in infected cats may resolve clinical signs of right-sided congestive heart failure and chylothorax. In addition, findings in one of these cats suggested that removal of all adult heartworms may not be necessary for resolution of clinical signs.

Most cats infected with *D immitis* harbor < 6 adult heartworms, with the median number of heartworms in infected cats being only 1.¹ Despite the generally low worm burden in cats, clinical signs such as dyspnea, coughing, and vomiting often develop,² and the mortality rate for cats with clinically apparent, naturally acquired heartworm disease is reported to be between 33% and 60%.^{2,3} In rare instances, infected cats may develop signs of right-sided congestive heart failure, chylothorax, or caval syndrome.⁴⁻⁷ In the 2 cats described in the present report, the heartworms interfered with tricuspid valve function, resulting in heart failure and, possibly, the early stages of caval syndrome as evidenced by the anemia in both cats and the mild bilirubinuria in 1.

Because of the serious complications associated with heartworm infection in cats, a safe, effective method of treatment is needed. However, there currently are not any safe, effective medical treatments for dirofilariasis in cats. In particular, use of injectable arsenicals such as sodium caparsolate and melarsomine may result in fatal pulmonary thromboembolism or acute lung injury,^{k,l} and medical adulticide treatment is currently not recommended. Cats with signs of respiratory tract disease have been treated long-term with corticosteroids to control inflammatory pulmonary disease, and thoracocentesis, diuretics, and quercetin-3-rutinoside have been used to treat congestive heart failure and chylothorax.⁸ However, as adult heartworms reach the end of their approximate 2-year lifespan, they may release large amounts of antigen or precipitate embolism, with potentially fatal results.^{9,m}

Previous authors have reported the use of various devices via a transvenous approach to remove adult heartworms from the right side of the heart and pulmonary arteries in cats and small dogs.^{4,5,10-13} Success has been reported with the use of Ishihara forceps, Jones forceps, and a horsehair brush.^{4,5,10-12} In a case series¹³ describing use of urologic stone retrieval baskets for removal of adult heartworms in 5 naturally affected cats, 3 of the cats survived surgery, and heartworms were removed from the right atrium or ventricle. In the remaining 2 cats, the heartworms were entangled, and 1 or more of the heartworms fragmented during removal through the jugular venotomy. Both cats immediately became hypotensive and died.

To our knowledge, the use of a nitinol gooseneck snare for removal of adult heartworms has not been reported previously. The snare seems to have advantages over previously described methods of heartworm extraction. Ishihara and flexible alligator forceps are of limited value in the retrieval of heartworms from small patients, as their size allows introduction only into the right atrium and proximal portion of the right ventricle. Like the gooseneck snare described in the present report, the horsehair brush is small enough and flexible enough to allow an experienced operator to advance it through the tricuspid and pulmonic valves. However,

unlike the horsehair brush, the gooseneck snare is protected by a catheter sheath and is less likely to damage endothelial surfaces during manipulations. The snare has an advantage over basket forceps in that it opens to a single loop, increasing the likelihood of worm retrieval. The operator is also able to control the extent of closure of the snare and thus may be less likely to traumatize ensnared heartworms.

Although heartworm retrieval was successful in the 2 cats described in the present report, there are substantial risks associated with the procedure. In particular, crushing or transecting the adult heartworms can induce a fatal shock reaction.^m Trauma to the jugular vein during multiple heartworm retrievals may result in transection of the vein. Whereas use of an introducing catheter would reduce the risk of jugular vein trauma, it would increase the risk of trauma to extracted heartworms as they pass through the introducing catheter. An important limitation to the procedure described in the present report was the need for fluoroscopic guidance during heartworm retrieval. Furthermore, in a study¹⁴ of 14 naturally infected cats with echocardiographic evidence of adult heartworms, it was found that 10 had heartworms in the pulmonary arteries, 6 had heartworms in the right atrium, 6 had heartworms in the right ventricle, and 1 had heartworms in the caudal vena cava. In another studyⁿ of 43 naturally infected cats with echocardiographic evidence of heartworms, 10 had heartworms in the right atrium or ventricle, and 33 had heartworms in the pulmonary arteries. Thus, retrieval of all heartworms may necessitate complicated manipulations within the right ventricle and pulmonary arteries in more than half of all infected cats. Unfortunately, the small size of the heart and pulmonary arteries in cats is not conducive to introduction of catheters and guide wires that allow direction of a retrieval apparatus into the more distal branches of the pulmonary arteries. In addition, there is a risk of inducing life-threatening arrhythmias, as was seen in 1 cat described in the present report, or of perforating the cardiac chambers or pulmonary arteries. On the other hand, findings for 1 cat described in the present report suggested that removal of all worms may not be a prerequisite for resolution of clinical signs.

- a. Microvena Corp, White Bear Lake, Minn.
- b. VICI model GC 501X oxygen alarm-monitor, Medtronic Inc, Poughkeepsie, Wash.
- c. Multistix, Bayer Healthcare LLC, Elkhart, Ind.
- d. Heartgard Chewables for Cats, Merial Ltd, Duluth, Ga.
- e. Animal Diagnostic Lab, St Louis, Mo.
- f. Cook Medical, Bloomington, Ind.

- g. Omnipaque, Nycomed Inc, Princeton, NJ.
- h. Fragmin, Vetter Pharma-Fertigung, Ravensburg, Germany; distributed by Pharmacia Corp, Kalamazoo, Mich.
- i. Enacard, Merial Ltd, Iselin, NJ.
- j. Rutin, Swanson Health Products, Fargo, ND.
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