

Percutaneous endovascular retrieval of an intravascular foreign body in five dogs, a goat, and a horse

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Case Description—5 dogs, 1 goat, and 1 horse underwent percutaneous endovascular retrieval of intravascular foreign bodies between 2002 and 2007.

Clinical Findings—Foreign bodies were IV catheters in 4 dogs, the horse, and the goat and a piece of a balloon valvuloplasty catheter in 1 dog. Location of the foreign bodies included the main pulmonary artery (1 dog), a branch of a pulmonary artery (4 dogs), the right ventricle (the goat), and a jugular vein (the horse).

Treatment and Outcome—The procedure of percutaneous endovascular retrieval of the foreign body was easy to perform in all instances. One dog was euthanized 41 days after retrieval because of worsening of another disease process, and 1 dog had abnormal neurologic signs secondary to a brain mass. All other animals were clinically normal during the follow-up period (follow-up duration, 3 to 57 months). None of the animals developed long-term complications secondary to the foreign body retrieval procedure.

Clinical Relevance—Intravascular foreign bodies that result from catheters or devices used during minimally invasive techniques are rare but may cause substantial morbidity. Percutaneous endovascular retrieval of intravascular foreign bodies was easily and safely performed in the 7 animals reported here. Use of percutaneous endovascular retrieval techniques should be considered for treatment of animals with intravascular foreign bodies because morbidity can be substantially decreased; however, proper selection of patients for the procedure is necessary. (*J Am Vet Med Assoc* 2008;232:1850–1856)

An 8-year-old castrated male Bearded Collie (dog 1) weighing 22.5 kg (49.5 lb) was referred to the Matthew J. Ryan Veterinary Hospital of the University of Pennsylvania after an IV catheter that had been placed in the right cephalic vein was inadvertently transected and the distal portion of the catheter migrated into a central segment of the venous system. Physical examination findings were unremarkable, but examination of ventrodorsal and lateral thoracic radiographic views revealed a radiopaque foreign body lodged in a distal branch of the right pulmonary artery (Figure 1).

Treatment options discussed with the owner included monitoring alone, percutaneous endovascular retrieval, and open surgical retrieval. The owner opted for us to proceed with percutaneous endovascular retrieval of the foreign body. The dog was anesthetized and positioned in dorsal recumbency. A 0.5-cm incision was made over the right jugular vein, and an 18-gauge IV catheter^a was advanced into the right jugular vein. Under fluoroscopic guidance, a 0.035-inch angled hydrophilic guidewire^b was advanced through the IV catheter and directed into the caudal vena cava (Figure 2). The IV

catheter was removed by pulling it out of the vessel over the guidewire. A 10-F vascular access sheath and dilator^c were advanced over the guidewire into the jugular vein, the dilator was removed, and the sheath was secured to the skin with a simple interrupted 3-0 nylon^d suture. The angled hydrophilic guidewire was directed through the right atrium and right ventricle and into the right pulmonary artery. An 8-F Balkin introducer set^e was introduced into the vascular access sheath and advanced over the guidewire into the main pulmonary artery, and the Balkin dilator was removed over the wire. A Berenstein catheter^f was advanced over the guidewire through the Balkin introducer sheath to the level of the pulmonary arteries, and the catheter and guidewire combination was used to gain access to the right pulmonary artery. The guidewire was removed, and a selective arteriogram was performed by injection of contrast material through the catheter to identify vascular anatomy of the right pulmonary artery. The catheter tip foreign body was identified in a secondary branch of the right pulmonary artery. The angled hydrophilic guidewire and catheter combination were directed by use of fluoroscopic guidance to gain access to the vessel that contained the catheter fragment. The guidewire was removed, and an endovascular snare^g was passed through the Berenstein catheter and repeatedly advanced past the fragment and withdrawn until the fragment was engaged. The Berenstein catheter was advanced over the snare to constrain the fragment, and the fragment, snare, and Berenstein catheter were all removed together through the Balkin introducer sheath.

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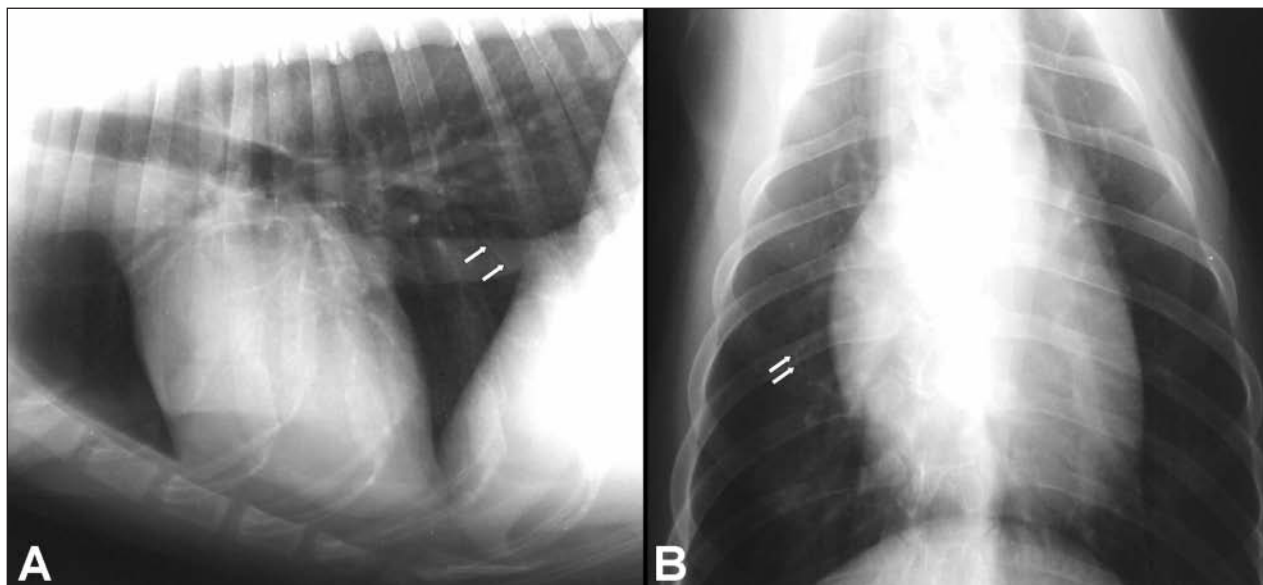


Figure 1—Lateral (A) and ventrodorsal (B) radiographic views of the thorax of an 8-year-old castrated male Bearded Collie (dog 1) with an IV catheter fragment (white arrows) in a branch of the right pulmonary artery.

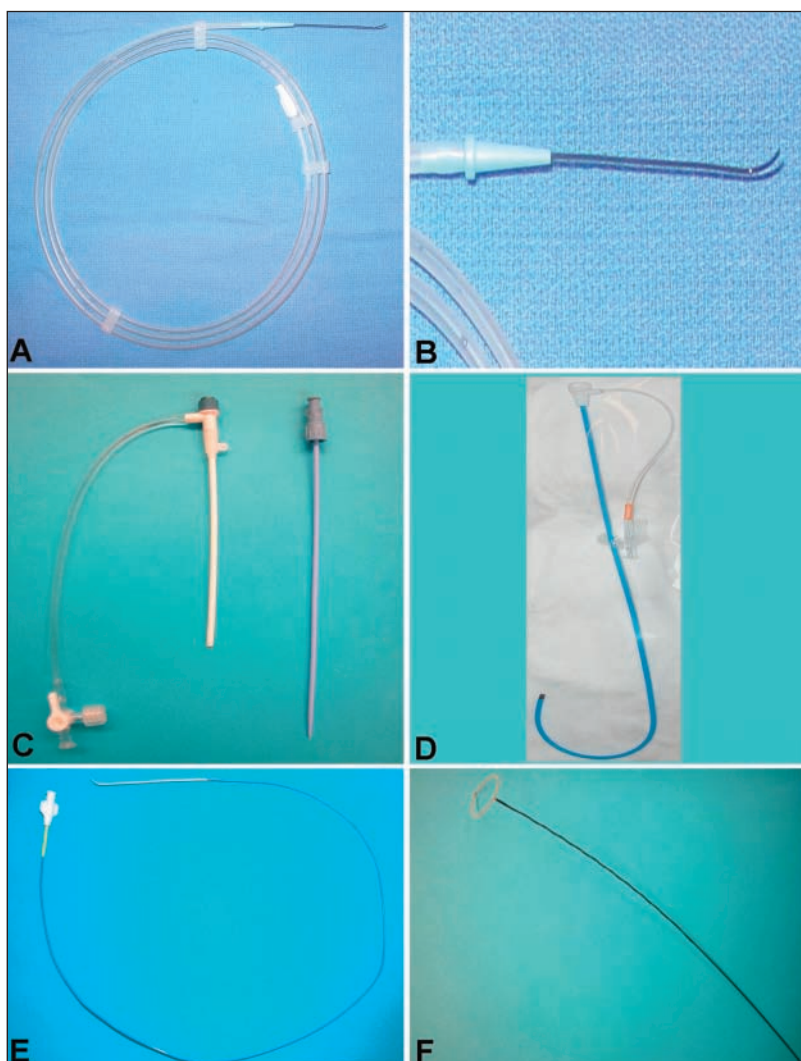


Figure 2—Photographs of instruments used for retrieval of a catheter foreign body. A—Hydrophilic guidewire. B—Close-up view depicting the end of the hydrophilic guidewire with a flexible tip. C—Vascular access sheath and dilator. D—Balkin introducer catheter. E—Berenstein catheter. F—Endovascular snare.

Another pulmonary arteriogram was performed to confirm vascular patency of the branch vessel and to confirm that there was no extravasation of contrast material or hemorrhage.

The guidewire was reintroduced into the vascular access sheath, and the vascular access sheath and Balkin introducer sheath were removed. A 7-F triple-lumen catheter^h was advanced over the guidewire to maintain vascular access and allow for progressive closure of the hole in the right jugular vein overnight. Duration for the foreign body retrieval procedure was 85 minutes.

Evaluation of ventrodorsal and lateral radiographic views obtained after the procedure revealed no abnormalities. The dog recovered well from anesthesia and was discharged later the same day. The triple-lumen catheter in the right jugular vein was removed the following day by the referring veterinarian. Ten months after the procedure, the dog was clinically normal.

A 3-month-old sexually intact male Boxer (dog 2) weighing 15.0 kg (33.0 lb) was admitted to the veterinary medical teaching hospital for correction of congenital valvular pulmonic stenosis by use of balloon valvuloplasty. The dog was anesthetized, and the pulmonary outflow tract was accessed. A 12-mm balloon valvuloplasty catheterⁱ was introduced and used to mechanically dilate the stenotic pulmonic valve. After dilatation, an intravascular foreign body (plastic sheath from the balloon valvuloplasty catheter) was identified fluoroscopically in the left pulmonary artery. The balloon valvuloplasty catheter was removed from

the vascular access sheath, and an endoscopic snare was introduced. The foreign body was removed successfully with the snare. The balloon valvuloplasty catheter was reintroduced, and further dilation of the pulmonic valve was performed successfully.

The dog recovered without complications from anesthesia. Duration of the entire procedure, including balloon valvuloplasty and foreign body retrieval, was 420 minutes. Duration of the foreign body retrieval procedure alone was 60 minutes. The dog was discharged from the hospital the next day, and it was examined 1 month after balloon valvuloplasty. Pulmonic valve stenosis was still detected, as was right atrial dilatation and right ventricular hypertrophy. The dog's cardiovascular status continued to deteriorate, and the dog was euthanized 41 days after the foreign body retrieval procedure. Postmortem examination was not performed.

A 5-year-old sexually intact male Bichon Frise (dog 3) weighing 8.7 kg (19.1 lb) was admitted to the veterinary medical teaching hospital for castration. During removal of the IV catheter from the right cephalic vein after surgery, it was noticed that the distal half of the catheter was missing. Thoracic radiographs were taken, and the catheter fragment was detected in a branch of the left pulmonary artery (Figure 3).

The owners elected to have the catheter removed 1 week later. The dog was anesthetized, and the procedure was performed as described for dog 1. Duration of the procedure was 45 minutes. The dog was discharged later on the same day and was clinically normal 13 months after the procedure.

A 9-year-old spayed female Toy Poodle (dog 4) weighing 3.2 kg (7.0 lb) was evaluated at the veterinary medical teaching hospital after an IV catheter in the ce-



Figure 3—Ventrodorsal fluoroscopic image of a 5-year-old sexually intact male Bichon Frise (dog 3) with a catheter foreign body (white arrow) in a branch of the left pulmonary artery.

phalic vein of the left forelimb was transected during removal at a referring veterinary clinic. Thoracic radiography revealed a catheter foreign body in a branch of the left pulmonary artery, and the owners elected to have the foreign body retrieved percutaneously. The dog was anesthetized, and the procedure was performed as described for dog 1. Transient arrhythmias (ventricular premature complexes) developed as the retrieval catheter was being manipulated and passed through the heart; however, no change in the dog's cardiovascular status was detected. Duration of the procedure was 75 minutes, and the dog was discharged from the hospital on the following day. The dog was clinically normal 5 months after the foreign body retrieval procedure.

A 10-year-old spayed female mixed-breed dog (dog 5) weighing 19.0 kg (41.8 lb) was referred to the veterinary medical teaching hospital for surgical removal of a previously diagnosed brain mass. Fourteen days prior to examination at our facility, the dog had several seizures and was admitted to the veterinary clinic of the referring veterinarian. An IV catheter was placed in the right saphenous vein for administration of anti-seizure medications. At the time of admittance to our facility, radiography was performed, which revealed a radiopaque foreign body in the right main pulmonary artery.

The dog was anesthetized, and surgery was performed to remove the brain tumor. Immediately after surgery, the foreign body removal procedure was performed, as described for dog 1. No complications were encountered during the procedure, and duration of the foreign body removal procedural was 40 minutes. This dog had no complications associated with the procedure when examined 2 months after foreign body removal.

A 2-year-old male Nubian goat weighing 70 kg (154 lb) underwent surgery for placement of a cystostomy tube at the George D. Widener Hospital at the New Bolton Center, University of Pennsylvania. Seven days after the surgery, it was noticed that an IV catheter in the right jugular vein had broken at the hub.

The right jugular vein was assessed ultrasonographically, but no foreign material was detected. Thoracic radiography was performed, which revealed a 7.7-cm linear, radiopaque foreign body in the right ventricle. Echocardiography was performed, which confirmed that the foreign body was wedged within the right ventricle between the septal leaflet of the tricuspid valve and the right ventricular free wall. A Holter monitor was placed on the goat so that a continuous ECG could be recorded during the subsequent 24 hours. Results revealed multiple ventricular premature contractions and couplets, triplets, and short runs of ventricular tachycardia.

During the next 5 days, the frequency of auscultable arrhythmic events increased. On day 13 of hospitalization, echocardiography was repeated and revealed no change in the position of the foreign body; however, during the echocardiographic examination, multiple episodes of ventricular premature contractions were detected. Endovascular removal of the foreign body was recommended.

The goat was anesthetized on the following day, and a 10-F vascular access sheath was placed in the

right jugular vein as was described for dog 1. A pig-tail catheter^j was advanced through the vascular access sheath into the right ventricle. The catheter was rotated manually by the operator under fluoroscopic guidance to dislodge the fragment and expose a free end. Once that had been achieved, an endovascular snare^k was introduced into the vascular access sheath. The free end of the catheter foreign body was grasped and removed with the snare. Duration of the endovascular retrieval procedure was 35 minutes.

The goat recovered from anesthesia without complications, and the cardiac arrhythmias resolved. The goat was discharged on day 15 and had not developed additional complications by 18 months after discharge.

A 4-month-old female Thoroughbred weighing 197 kg (433 lb) was admitted to the veterinary medical teaching hospital at the New Bolton Center for evaluation after an IV catheter broke at the hub. The catheter shaft was presumed to have migrated centrally. Initial examination at the time of arrival at the facility revealed that the foal was bright, alert, and responsive; however, a firm, raised, 1-cm² swelling was detected over the jugular vein, approximately 2 cm distal to the site of catheter entry. The swelling was localized to the subcutaneous tissues, and palpation of the swelling did not induce signs of pain. No other abnormalities were detected during physical examination.

Thoracic radiography was used to determine whether a catheter fragment was lodged in the right heart chambers or pulmonary arteries. No intravascular foreign bodies were evident radiographically, and all lung fields appeared normal. Echocardiography was performed in an effort to locate the catheter fragment within the heart. No foreign bodies or other abnormalities were evident ultrasonographically in the heart.

The left jugular vein was examined ultrasonographically from the site of insertion of the catheter to the thoracic inlet. A 6-cm echogenic linear foreign body was detected in the jugular vein near the thoracic inlet, approximately 10 cm distal to the site of catheter entry. The distal tip of the fragment appeared to be lodged in the wall of the vein. Ultrasonographic examination of the swelling revealed a 2-cm linear foreign body within the subcutaneous tissues at the site of the swelling (Figure 4). The foreign body was assumed to be the broken catheter fragment.

Retrieval of the catheter fragments located within the jugular vein and within the subcutaneous tissues was discussed with the owner. The owner consented to anesthesia of the foal for percutaneous retrieval of the fragments. An 11-F vascular access sheath was placed percutaneously in the left jugular vein immediately caudal to the angle of the mandible. An 8-F guiding catheter was introduced into the vascular access sheath and carefully advanced beyond the distal end of the foreign body. An endovascular snare was advanced through the catheter until the loop of the snare was fluoroscopically visible. The catheter and snare were advanced and withdrawn together until the loop of the snare engaged the distal tip of the foreign body. Once the foreign body was secured by the snare, the catheter, snare, and foreign body were withdrawn together through the sheath. The sheath was removed, and manual compression was applied for 5 minutes to achieve hemostasis. The frag-

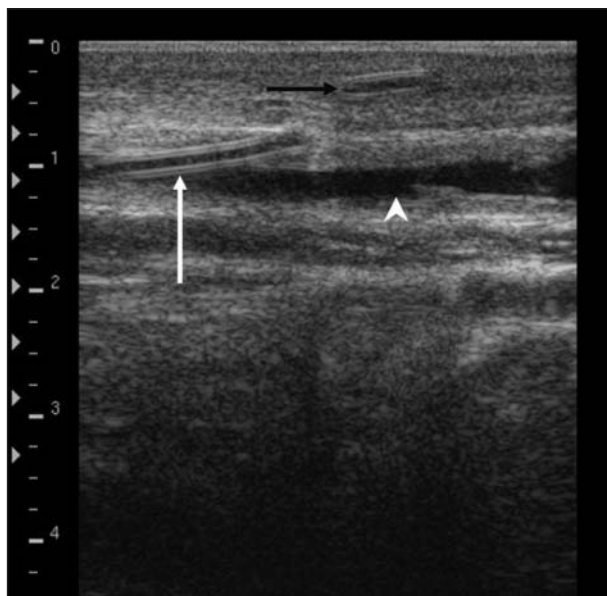


Figure 4—Ultrasonographic image of the left jugular vein in a 4-month-old female Thoroughbred. Notice the large catheter fragment (white arrow) lodged in the wall of the jugular vein and a smaller fragment lodged in the subcutaneous tissues (black arrow). The jugular vein wall is indicated (arrowhead). The scale on the left side is in centimeters.

ment in the subcutaneous tissues was removed by blunt dissection, with fluoroscopic guidance used to precisely locate the fragment. Skin overlying the site of the fragment in the subcutaneous tissues was closed with 2-0 polydioxanone^l suture material in a simple continuous pattern. Fluoroscopy performed at the end of the procedure revealed no residual fragments of the foreign body. Duration of the foreign body retrieval procedure was 35 minutes.

The foal recovered without complications from anesthesia. One day following removal of the catheter fragments, the foal was discharged from the hospital. A follow-up conversation with the owner 58 months after the foal was discharged from the hospital revealed that it was doing well and had no apparent complications from the catheter removal procedure.

Discussion

Use of an intravascular catheter for administration of fluids and medications or for monitoring blood pressure is a common practice. Although rare, breakage or dislodgement of part of the intravascular catheter is a known complication of the use of intravascular catheters. The increasing popularity of endovascular techniques involving the use of guidewires, specialized catheters, coils, and stents will likely result in increasing numbers of intravascular foreign bodies in veterinary patients. This trend has been seen in human medicine during the past 20 years, and the numbers of intravascular foreign bodies diagnosed have been equally distributed between intravascular catheters and devices used in minimally invasive procedures.¹⁻⁴

Although there are reports^{5,6} of foals and adult horses in which intravascular foreign bodies do not result in clinical signs in the immediate period after frag-

mentation, catheter fragmentation in foals has resulted in life-threatening cardiac perforation.⁷ Percutaneous removal of catheter fragments from the right ventricle or pulmonary artery of foals has been reported.^{5,8,9} To the authors' knowledge, the use of percutaneous techniques for endovascular retrieval of a foreign body has not been evaluated clinically in dogs and goats.

Catheter foreign bodies should be suspected when a catheter is removed and a piece of the catheter is inadvertently transected or released into the vessel or the catheter is noticed to be incomplete. Further diagnostic tests are necessary to locate the missing part of the catheter or catheter fragments. In humans, a third of intravascular foreign bodies are detected in the pulmonary arteries.¹⁰ The next most common locations are the great veins, right ventricle, right atrium, and periphery of the lungs.¹⁰ For the 7 animals in the study reported here, location of the foreign body included the main pulmonary artery (1 dog), a branch of a pulmonary artery (4 dogs), the right ventricle (1 goat), and a jugular vein (1 horse).

Many catheters have radiopaque components and thus can be detected radiographically.¹¹ Foreign bodies that are the result of a minimally invasive procedure are usually recognized during the procedure, at subsequent evaluations, or when the animal is evaluated for sudden onset of clinical signs related or unrelated to the original problem. Fluoroscopy and ultrasonography may also be useful, and computed tomography is commonly used in humans (with or without angiography) to localize foreign bodies or foreign body-associated thrombi.¹²

Diagnostic tests used in the animals described here included radiography, ultrasonography, and fluoroscopy. All of these modalities were found to be useful in the diagnosis of the intravascular foreign bodies in the animals of this report. The intravascular foreign body was successfully identified in 5 animals (4 dogs and the goat) in which thoracic radiographic views were obtained. Ultrasonography was useful in the diagnosis of a foreign body in the horse and goat.

Use of fluoroscopy during foreign body removal is essential. This technique allows for real-time evaluation of the vasculature and identification of the foreign body. Additionally, *in vivo* manipulation of instruments necessitates that fluoroscopy be used. The foreign body was successfully identified by use of fluoroscopy in all 7 animals.

Attempted removal of an intravascular foreign body should be carefully considered. The risks associated with removal of the foreign body must be weighed against the risk of leaving the foreign body *in situ*. Complications resulting from intravascular foreign bodies are serious and diverse, but attempted removal of intravascular foreign bodies is considered the standard-of-care in human medicine.¹¹ In humans, the rate of development of substantial complications without death secondary to catheter foreign bodies ranges from 21% to 33%.^{3,10,13} However, mortality rates as high as 60% have been reported.^{3,14} Causes of death include cardiac perforation (32%), pulmonary thrombosis (23%), endocarditis (16%), sepsis (16%), and arrhythmias (13%).^{10,13} Other nonfatal complications include renal and adrenal gland infarction and caval syndrome.¹⁰

Less information is available regarding complications associated with devices used in minimally invasive techniques.^{15–17} Stents can cause thrombosis or vascular wall perforation. A migrated stent has resulted in cardiac perforation.¹⁵ In addition, coils have strong thrombogenic potential, and migration away from the desired site into an inappropriate vessel can lead to ischemia. In 1 study,¹⁸ 24 of 115 (21%) dogs with a patent ductus arteriosus that were treated by transarterial coil occlusion had coils that migrated into another vessel (pulmonary artery [*n* = 18 dogs], femoral artery [5], and celiac artery [1]). Of those, only the dog with occlusion of the celiac artery developed short-term complications. That dog developed ischemia of the gastrointestinal tract and was eventually euthanized. In another study,¹⁹ coils that migrated in 7 patients resulted in pulmonary embolization without complications.

Criteria for patient selection for removal of an intravascular foreign body in veterinary medicine are difficult to establish because the complication rate in animals that do not undergo foreign body removal has not been determined. It would appear reasonable to recommend attempted retrieval in animals with hypercoagulable states secondary to hyperadrenocorticism, protein-losing nephropathy or enteropathy, or pancreatitis. However, such animals may also have potential concurrent conditions that preclude them from the procedure, and anesthesia alone may further compromise health in certain circumstances.

Other candidates for foreign body retrieval are those with preexisting cardiac arrhythmias or immunosuppressive conditions. Because intravascular foreign bodies can result in the perpetuation of arrhythmias, animals with preexisting arrhythmias may become further destabilized. Those receiving immunosuppressive medications or that have a disease that causes immune system compromise may be more likely to develop a septic thrombus. Sepsis is of particular concern in humans with intravascular catheter foreign bodies because intravascular catheters allowed to remain indwelling for > 48 hours have a 52% chance of bacterial contamination.²⁰ None of the retrieved foreign bodies reported here were submitted for bacterial culture, although such testing is indicated on the basis of the findings in the human literature.

Size of the animal is likely to be prohibitive only when the animal is too large for fluoroscopy to be a useful tool. The smallest patient treated in this study weighed 3.2 kg, and in this animal, size was not prohibitive. Percutaneous removal of a catheter has been successfully performed in an 800-g premature human infant.²¹

Chronicity of a foreign body is not necessarily a contraindication for retrieval. A chronic foreign body (ie, dwelling intravascularly for > 24 hours)²² is more likely to be adhered to the vessel wall, but studies^{22,23} in humans reveal that foreign bodies can be removed even up to 11 years after initial embolization. Of the 7 animals described here, the foreign body would have been considered chronic on the basis of this classification in 6, and the removal procedure in those 6 animals was not noted in the records to be difficult.

Until recently, an open surgical procedure was the only option for removal of intravascular foreign bod-

ies and was rarely performed because of the potential associated morbidity. When surgical intervention is necessary, lateral thoracotomy or median sternotomy is typically performed. These procedures can involve considerable morbidity, and potential complications (such as hemorrhage, lung damage, anesthetic risk, postoperative pain, and death) must be considered.²⁴ Interventional radiologic techniques have simplified the retrieval procedure, and it is now possible to perform this procedure in a minimally invasive manner.

The loop snare technique has been extensively evaluated, is minimally invasive, and is the method of choice for most radiologists conducting interventional techniques.^{1,2,4,13} For successful use of the loop snare technique, a free end of the foreign body must be accessible.⁴ When the foreign body is positioned such that both ends are lodged against the vessel walls, another device, such as a hooked catheter, hooked guidewire, or IV forceps, may be used to reposition the foreign body and expose a free end.^{2,13,24} These devices have resulted in successful foreign body removal when used alone or with a loop snare.^{2,13,24}

The loop snare technique was used in all of the animals in the study reported here. In the goat, a free end was not exposed, and manipulation of the foreign body with a pigtail catheter was necessary to enable snaring of the foreign body. The loop snare technique was easy to perform in all of the animals, regardless of foreign body location.

Percutaneous removal of an intravascular foreign body in humans has a reported^{2,25,26} success rate of 90% to 100%. Complications associated with this procedure include transient arrhythmias and unsuccessful removal of the foreign body. These outcomes have rarely been reported,^{10,26} perhaps because instances of failed removal are unlikely to be published.

The only complication encountered during foreign body retrieval in the animals of our report was the development of cardiac arrhythmias. Arrhythmias were transient and did not result in cardiovascular compromise. However, long-term follow-up monitoring of the animals was variable, and the small number of animals prevented a true prediction of the extent of complications.

With proper case selection in mind, it is important to consider removal of intravascular foreign bodies in companion animals because severe sequelae can develop. Similar to the situation in humans, the use of percutaneous, minimally invasive intravascular techniques in companion animals is gaining popularity. Although intravascular foreign bodies are still an uncommon clinical entity, the increased use of minimally invasive interventional techniques in veterinary medicine will likely lead to an increased frequency of this complication. A complete understanding of vascular anatomy and procedural techniques for the removal of these foreign bodies is required to optimize success. In the series of animals described here, each of which underwent a procedure for retrieval of an intravascular foreign body, percutaneous endovascular techniques enabled rapid and easy removal of intravascular foreign bodies by use of fluoroscopy.

- a. Veni-Systems Clear Cath, Abbott Laboratories, Sligo, Ireland.
- b. Weasel wire, Infiniti Medical LLC, Haverford, Pa.
- c. Intradyn arterial hemostasis introducer, B Braun Medical, Bethlehem, Pa.
- d. Ethicon Inc, Somerville, NJ.
- e. Cook Inc, Bloomington, Ind.
- f. Infiniti Medical LLC, Haverford, Pa.
- g. Goose neck snare, ev3, Plymouth, Minn.
- h. Arrow-Howes multilumen central venous catheterization set with Blue FlexTIP catheter, Arrow International Inc, Reading, Pa.
- i. Berman angiographic balloon catheter, Arrow International Inc, Reading, Pa.
- j. Performa 4 Fr straight cardiac pigtail catheter, Merit Medical Systems Inc, South Jordan, Utah.
- k. Amplatz goose-neck snare, Microvena Corp, White Bear Lake, Minn.
- l. PDS, Ethicon Inc, Somerville, NJ.

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