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EMERGENCY AND CRITICAL CARE OF FERRETS

Connie J. Orcutt, DVM, ABVP–Avian

The American Veterinary Medical Association recently reported an increase from 275,000 in 1991 to over 700,000 in 1996 in the population of pet ferrets in the United States.[14] Increasingly, small-animal practitioners are being presented with ferrets for evaluation and treatment of clinical emergencies. Although certain diseases affecting ferrets are similar to those involving dogs and cats, other syndromes present quite differently or are unique to ferrets. This article presents an overview of emergency diagnostic and treatment procedures along with a discussion of diseases that most commonly affect the ferret presenting in crisis.

Signalment and history are crucial in forming an initial list of differential diagnoses in any emergency situation. The average life span for a ferret in the United States is from 5 to 7 years.[9] Insulinoma, adrenal gland disease, and cardiomyopathy each occurs with greater frequency in middle- to older-aged ferrets,[25, 43, 47] whereas mediastinal lymphosarcoma or ingestion of rubber or sponge foreign bodies most often involves younger animals.[2, 38] Exposure to a new ferret may raise the suspicion of infectious disease that can affect a ferret of any age. Ferrets are also susceptible to influenza strains that affect people. It is important to determine whether clinical signs are acute or chronic and to note historical abnormalities affecting any body system.

HANDLING

The critically ill ferret may be listless, requiring minimal restraint. Knowledge of handling is crucial, however, because ferret bites in some

From the Department of Avian and Exotic Pet Medicine, Angell Memorial Animal Hospital, Boston, Massachusetts

localities mandate euthanasia of the animal for rabies testing.[7] If the ferret is active yet tractable, support the body vertically under the forelimbs for examination. With more energetic ferrets or those prone to biting, scruffing and holding the patient vertically elicits relaxation and a yawning reflex. Distraction is afforded by offering Nutri-Cal (EVSCO Pharmaceuticals, Buena, NJ) or Ferretone (8-in-1 Pet Products, Hauppauge, NY), but avoid sugary treats in ferrets suspected of insulinoma. Fractious ferrets can be scruffed in lateral or sternal recumbency with one hand while placing the other hand cranial to the pelvis and stretching the body slightly.[7]

PHYSICAL EXAMINATION

Awareness of specific anatomic, physiologic, and behavioral characteristics of the ferret is important for accurate clinical assessment. Modify the extent of the physical examination based on the ferret's status. Dyspneic animals may tolerate only brief periods of handling without oxygen supplementation. Bruxism, ptyalism, or pawing at the mouth most often indicates gastrointestinal discomfort or nausea resulting from hypoglycemia or other causes. Hypoglycemic ferrets may also appear dazed. Posterior paresis in the ferret can be a manifestation of hypoglycemia, neurologic disease, or weakness of any cause.

The ferret's normal body temperature is 100° to 103° F.[42] Testing the hydration status of a ferret by tenting the skin can be inaccurate, and evaluating mucus membrane capillary refill time is generally a more reliable method. The normal heart rate of 180 to 250 beats/min often varies greatly due to the ferret's normal respiratory sinus arrhythmia.[42] The thorax is long relative to the total body length of a ferret, and the entire area must be ausculted for murmurs or abnormal arrhythmias. Splenomegaly is a common finding in many ferrets, but pronounced splenomegaly or abnormal splenic texture may indicate pathology.

Most pet ferrets in the United States originate from large breeding facilities in which kits are neutered at 5 to 6 weeks of age, and a tattoo is placed inside the right pinna. Although this makes disease involving the reproductive tract less likely, it does not preclude the presence of a reproductive remnant. A swollen vulva in a female ferret may indicate adrenal disease (most commonly, especially in middle- to older-aged animals),[42] an intact female in estrus, or the presence of an ovarian or uterine remnant. Male ferrets have an os penis, and the prepuce is located on the ventral abdomen.

HOSPITALIZATION AND NUTRITIONAL MAINTENANCE

Caging

The critically ill ferret is optimally hospitalized in a quiet area separate from dogs and cats. Isolation areas must be available for pa-

tients suspected of having infectious disease (for example, canine distemper virus or epizootic catarrhal enteritis). Hospital personnel with influenza should avoid contact with ferrets.

The ferret requiring supplemental oxygen or heat can be hospitalized in the same type of oxygen cage or incubator used for a dog or cat. Alternatively, ferrets can be placed in acrylic intensive care cages designed for birds.[42] Monitor ferrets in incubators carefully to prevent hyperthermia. The normothermic, eupneic ferret hospitalized in a well-ventilated cage must also be monitored closely to prevent hypothermia. Placing a towel or disposable diaper in the cage discourages the ferret from expending energy while attempting to burrow under cage paper.

Nutrition

Anorectic ferrets are at risk of developing hepatic lipidosis or hypoglycemia. Enteral feeding is recommended whenever possible. Debilitated ferrets refusing their regular food often accept syringe feeding or soft foods offered on a tongue depressor. A/D diet (Hills Pet Products, Topeka, KS) provides an easily digestible diet accepted by most ferrets. Syringe feeding is dosed at 2–5 mL three to four times daily.[42] Supplements such as Nutri-Cal or Deliver 2.0 (Mead Johnson, Evansville, IL) provide additional calories when added to syringe-fed foods, but these sources are not nutritionally complete for ferrets and should not be fed as their sole diet for extended periods.[42] Nutri-Cal and other sugar-containing formulations can cause rebound hypoglycemia in ferrets that have insulinoma and should be avoided in those animals. Raw meat or eggs that may contain bacterial pathogens are also not recommended.

Pharyngostomy tube placement in ferrets has been described.[7] The technique is identical to that described for cats and utilizes an 8 to 10 Fr pediatric feeding tube.

In cases of protracted diarrhea or vomiting, gastrointestinal ulceration, or resistance to syringe feeding, a total nutrient admixture (TNA) has been used successfully to provide parenteral nutrition (PN) to more than 10 ferrets in the author's clinical practice. If a veterinary practice does not have the capability to compound parenteral solutions, some human hospitals mix PN solutions in their own pharmacies and will formulate a bag of TNA for a veterinarian when provided with a prescription (Table 1). A mixture of lipid and dextrose provides the ferret's resting energy requirement (Rebecca Remillard, PhD, DVM, ACVN, Angell Memorial Animal Hospital, Boston, MA, personal communication, November 1997). This mixture is supplemented with amino acids, electrolytes, water-soluble vitamins, and minerals, and fluid is added so the total solution meets daily fluid volume requirements. Such all-in-one solutions can be refrigerated for at least 7 days. A silicone elastomer or polyurethane jugular catheter (Cook Veterinary Products, Bloomington, IL) is recommended for delivery of the solution by infusion pump.

Table 1. TOTAL NUTRIENT ADMIXTURE FORMULA FOR A 1-KG FERRET

Patient requirements:	
Body weight	1 kg (2.2 lb)
Resting energy requirement (RER)	70 kcal/d (RER = 70 × $BW_{kg}^{0.75}$)
Calories from glucose	10%
Calories from fat	90%
Protein intake	3 g/100 kcal
Potassium supplementation	30 mEq/L fluids administered
Daily fluid rate	70 mL/kg/d
Parenteral solution:	
50% dextrose	4 mL providing 6.8 kcal
20% lipid	32 mL providing 64 kcal
8.5% amino acid solution w/electrolytes	25 mL (2.8 g amino acids)
Vitamin B*	1.0 mL (1 mL/100 kcal)
Micro minerals†	1.0 mL (1 mL/100 kcal)
KCl	0.5 mL (1 mEq/mL solution)
(1 mEq from amino acid solution and Lactated Ringers also)	
Lactated Ringers	9 mL (can adjust as fluid requirements change)
Total fluid volume	71 mL
This final solution in a liter bag contains 88 kcal (90% from fat), adequate nitrogen, major B vitamins with the following electrolyte profile:	
Sodium	41.3 mEq/L
Potassium	29.66 mEq/L
Magnesium	3.46 mEq/L
Phosphate	10.4 mEq/L
Chloride	38.5 mEq/L
Calcium	0.35 mEq/L
Final osmolarity = 648 mOsm/L	

*B-Vitamin Complex containing 50 mg thiamine, 2 mg riboflavin, 100 mg niacin, 2 mg pyridoxine, 10 mg pantothenic acid, 0.4 ppm B_{12} per mL (Butler Co., Columbus, OH)

†MTE-4 containing 1-mg zinc, 0.1-mg manganese, 0.4 mg copper, 4-μg chromium per mL (Fujisawa USA, Inc., Deerfield, IL)

Hospitalized ferrets eating voluntarily and without special dietary requirements are optimally provided with their regular diet. Otherwise, offer a premium-quality dry cat, kitten, or ferret food. Ferrets have high fat and animal protein requirements and metabolize fat more efficiently for energy than carbohydrates.[7]

If a ferret requires fasting before surgery for the evaluation of blood glucose or for radiographic examination of the gastrointestinal tract, do not withhold food for more than 6 hours.[6] Ferrets with insulinoma are especially at risk for developing profound hypoglycemia during extended periods of fasting.

DIAGNOSTIC AND TREATMENT TECHNIQUES

Blood Collection

The critically ill ferret should be stabilized before pursuing extensive diagnostics. However, even severely compromised ferrets usually toler-

ate the sampling of a small volume of blood from a peripheral vein for estimated blood glucose (BG), total protein (TP), packed cell volume (PCV), and blood urea nitrogen (BUN) measurements.

Use an insulin syringe with a 28-gauge needle for collecting small volumes of blood (<0.5 mL) from either the lateral saphenous or cephalic vein. Visualization of peripheral veins is facilitated by using a 1/4-in. Penrose drain as a tourniquet.

For larger volumes of blood, the jugular vein or anterior vena cava are preferred sites of venipuncture. A healthy ferret's blood volume is approximately 5% to 6% of its body weight.[7] As much as 10% of the blood volume can be safely withdrawn in a healthy ferret.[7, 42] Determine the ferret's initial PCV and level of hydration before withdrawing substantial volumes of blood. For jugular venipuncture, use a 25-gauge needle on a tuberculin or 3-mL syringe. Hold the ferret at a table's edge or in lateral recumbency as for a cat, or alternatively, wrap the ferret in a towel and restrain in dorsal recumbency.[7] The ferret's jugular vein lies more lateral than that in a dog or cat.[7, 42]

Venipuncture of the anterior vena cava for ferrets has been described.[42] This procedure can be performed without sedation in a debilitated ferret. However, if the patient resists restraint or the practitioner is inexperienced with this technique, anesthesia may be required. Restrain the ferret in dorsal recumbency while one assistant extends the forelimbs caudally and a second assistant stretches the body with gentle traction applied cranial to the pelvis (Fig. 1). Palpate a slight depression at the thoracic inlet lateral to either side of the manubrium and cranial to the

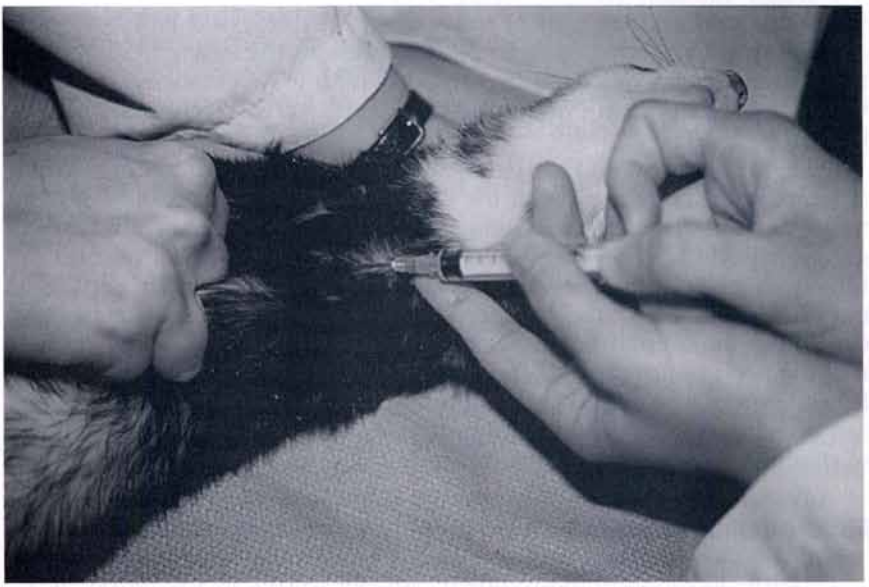

Figure 1. Restraint of ferret during anterior vena cava venipuncture.

first rib. Approach the site at a 45° angle to the skin while aiming toward the opposite hip. Insert a 25-gauge needle attached to a 3-mL syringe up to the needle hub. Apply negative pressure, and slowly withdraw the needle until blood begins to fill the syringe. Withdraw the needle if the ferret struggles. It is not necessary to apply pressure to the venipuncture site after the sample is collected.

A method for obtaining volumes of as much as 1.0 to 1.5 mL of blood from the ventral tail artery of ferrets has been described.[7] This procedure is painful to perform in the unanesthetized patient. Restrain the ferret in dorsal recumbency. Insert a 22-gauge needle attached to a syringe along the ventral midline of the tail, 2 to 5 cm distal to the tail base. Direct the needle at a shallow angle toward the body while gently aspirating.

Catheter Placement

Peripheral catheterization can be performed in the awake debilitated ferret, but more active ferrets often require anesthesia. Use a 22- or 24-gauge peripheral catheter for placement in the lateral saphenous or cephalic vein. To facilitate intravenous (IV) catheter placement, first puncture the skin overlying or adjacent to the vein with a 20- or 22-gauge needle while being careful to avoid the vein. Secure the catheter with sterile tissue glue or a tape butterfly sutured to the skin before bandaging the leg.

For jugular catheterization, the author most often uses a 22-gauge, 8-in. through-the-needle catheter on a 19-gauge needle (Intracath, Becton Dickinson Vascular Access, Sandy, UT). A cutdown procedure may be necessary to access the vein. Ferrets often act depressed with a jugular catheter and neck bandaging in place. Access to the vascular system for more than several days can be achieved with a subcutaneously placed vascular access system (Vascular-Access-Port, Access Technologies, Skokie, IL).[44]

An intraosseous (IO) catheter can be placed in the humerus, femur, or tibia, with the femur being the site least likely to impede the ferret's movement.[4,7] Use a 20- or 22-gauge, 1.5-in. spinal needle or a 20- or 22-gauge hypodermic needle with a sterile surgical wire inserted into the lumen as a stylet to prevent occlusion of the needle with a plug of bone.[7,42] Placement of the catheter is done with the ferret under anesthesia unless the animal is very debilitated. Alternatively, the soft tissues and the periosteum can be blocked with local anesthetic.[4] The technique for catheter placement is the same as that described for a cat. IO catheters can be left in place for several days during which time prophylactic use of parenteral antibiotics is recommended.[7]

Fluid Administration

Maintenance fluid requirement for the ferret is estimated at 70 mL/kg/24 h.[7] Calculate additional fluid requirements for correction of

dehydration and compensation for ongoing losses following protocols used for small animals. IV or IO fluid delivery is recommended in severely debilitated ferrets requiring dextrose supplementation. Continuous delivery of fluids using an infusion pump is recommended. Alternatively, a Buretrol device (Baxter Healthcare, Deerfield, IL) can be used to deliver small fluid volumes.[42] Monitor the ferret carefully for overhydration, which may first be evident by auscultation of harsh lung sounds or a heart murmur. Ferrets with cardiac disease are especially at risk of overhydration. Debilitated, anorectic animals may require fluids supplemented with dextrose, vitamin B, and potassium following the protocols used for small animals.[42] In cases of protracted anorexia, a TNA delivered IV can be substituted for this fluid mix. Use only small volumes of heparinized saline when flushing any catheter in the ferret to prevent heparin overdosage.

Administering Medications

Antibiotics and most other medications are administered at dosages used with cats on a per kilogram basis.[42] When an indwelling catheter is not in place, use a 25-gauge butterfly catheter for IV medications. Most medications given intravenously, with the exception of some chemotherapeutic drugs, can alternatively be administered via an IO catheter.[7] Limit the use of intramuscular (IM) medications in ferrets owing to their reduced muscle mass.[42] This author prefers the quadriceps for IM injections because of its increased mass and the reduced risk of iatrogenic nerve damage at this site compared with the caudal thigh. Administer subcutaneous injections as for a dog or cat.

Oral medications are best administered in liquid form, because pill administration is difficult in ferrets.[42] Most tablets can be crushed and compounded into a suspension with a vehicle such as Ora-Plus (Paddock Laboratories, Inc., Minneapolis, MN), flavoring, and water in a 1:1:2 ratio.[51] Refrigerate the medication and shake well before using. There is no guarantee of stability.[51]

Blood Transfusions

Transfusion in the ferret has been recommended when the PCV drops below 12% to 15%, depending on whether the anemia is acute or has developed gradually.[42] Blood groups have not been demonstrated in ferrets, and there is little risk of a transfusion reaction even without crossmatching and after using a variety of donors.[7, 33, 42] Estimation of the blood volume required by the recipient can be calculated as for a cat.[30]

$$\text{anticoagulated blood volume (mL)} = \text{body weight (kg)} \times 70 \times \frac{\text{PCV desired} - \text{PCV of recipient}}{\text{PCV of donor in anticoagulant}}$$

Place a 22-gauge jugular catheter or a 20-gauge IO catheter for transfusion delivery. The author treats the recipient 15 minutes before transfusion with a slow IV bolus of a short-acting corticosteroid (prednisolone sodium succinate at 22 mg/kg or dexamethasone sodium phosphate at 6- to 8-mg/kg).[13]

Choose a clinically normal ferret (PCV at least 44%) as a donor.[42] The author collects a maximum blood volume (milliliter) equivalent to 0.6% of the donor's body weight. Use a 21-gauge butterfly catheter on a 6- to 12-mL syringe for blood collection. An acid-citrate-dextrose (ACD) solution is used as an anticoagulant. Flush the needle, tubing, and syringe with ACD before collection, and use 1.0 mL ACD per 6.0 mL whole blood collected from the anesthetized donor ferret.[42] Whole blood can be transfused immediately with a slow bolus or with a syringe pump.[7, 33, 42]

Cystocentesis and Urethral Catheterization

Sedation is recommended for cystocentesis in all but very debilitated ferrets, because the bladder wall is thin and can be easily lacerated if the patient struggles.[7] Use a 25- or 28-gauge needle for cystocentesis.

Urethral catheterization requires anesthesia even with depressed patients. Most cases of urethral obstruction involve male ferrets and are the result of cystic calculi or hyperplastic prostatic-like tissue at the neck of the bladder.[7] Catheterization of the male is complicated by the J-shaped os penis as well as the very small diameter of the penile urethra. Place the male in dorsal recumbency, and aseptically prepare the prepuce. If the prepuce or tip of the penis is swollen, a small incision can be made in the preputial opening to exteriorize the penis.[7] The tissue covering the os penis is very thin. A surgical loupe aids visualization of the small penile urethral opening lying on the ventral surface of the penis several millimeters proximal to the tip of the os. A 24-gauge pediatric catheter with the stylet removed can be used to localize the urethral orifice (Fig. 2). Flush the catheter with sterile saline if resistance is met while catheterizing the urethra. In some cases, a 3.5-Fr rubber feeding tube can be used as an indwelling catheter, but this will be too large in many ferrets. The author most often uses a 20- or 22-gauge, 8-in. jugular catheter with the stylet removed (see the section on IV catheterization). The stylet can be left in place with the end retracted to provide support around the pelvic flexure, but exercise extreme caution to avoid perforation of the urethra. Suture the catheter to the skin using tape butterflies, and tape the administration port of the catheter to a tongue depressor to prevent kinking. Place a padded bandage taped to the skin, and attach the catheter to a closed urinary collection system. Monitor the ferret carefully, because many animals attempt to remove the bandage and catheter. The ferret with an indwelling urinary catheter should be treated empirically with a broad spectrum antibiotic (see the section on cystitis).

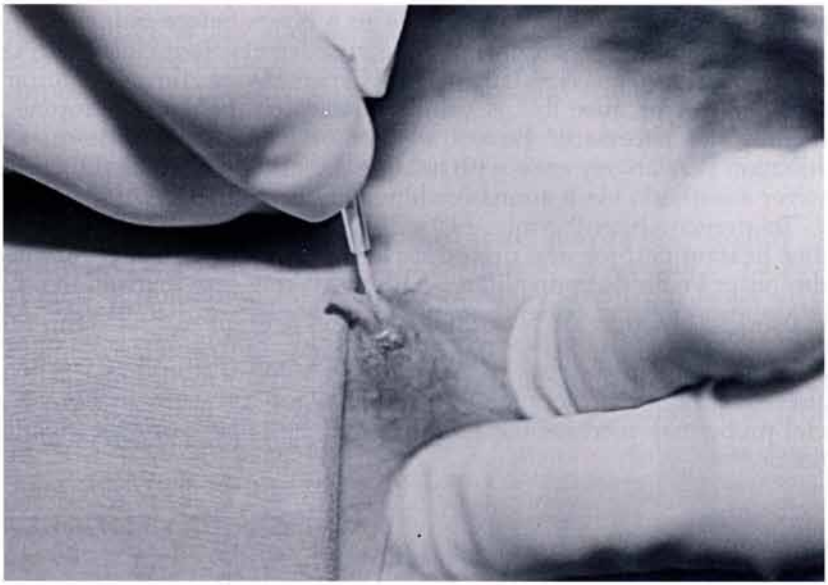

Figure 2. Urethral catheterization of the male ferret.

For catheterization of the female ferret, place the anesthetized patient in ventral recumbency, elevate the hindquarters, and aseptically prepare the vulva and perivulvar area. Use a small vaginal speculum or otoscope cone to locate the urethral opening on the ventral floor of the vaginal vestivule, approximately 1 to 1.5 cm cranial to the clitoral fossa.[7, 42] Use a catheter as described above for the male ferret.

Tube Thoracostomy

In some instances of pneumothorax or pleural effusion, placement of a chest tube may be required. The author has performed this technique as described for a cat by using, as a chest tube, an 8-Fr rubber feeding tube with a Kirschner wire stylet. Once sutured in place, the tube is capped for intermittent suction. The author has successfully used continuous suction at 13 to 15 cm H_2O-negative pressure in one case of a ferret with a continuous spontaneous pneumothorax.

ANESTHESIA, SURGERY, AND ANALGESIA

Anesthesia and Surgery

Isoflurane provides the safest means of anesthesia in the critically ill ferret. Avoid the use of injectable agents in debilitated animals.[35]

Ideally, a ferret should be fasted for 4 to 6 hours before induction. An induction chamber is recommended, because ferrets often violently resist induction by face mask. Many ferrets hypersalivate during isoflurane induction, but because this is usually a transient behavior, atropine is generally not necessary.[7] Ferrets are not prone to laryngospasm, and intubation is relatively easy with a 2.0 to 4.0 mm endotracheal tube.[35, 37] Deliver anesthesia via a nonrebreathing circuit.

To prevent hypothermia, place the ferret on a circulating warm water heating pad for any procedure lasting more than a few minutes. Administer IV fluids to debilitated patients, taking care to avoid overhydration, especially in patients suspected of having cardiac disease. Administer 2.5% to 5% dextrose-containing fluids to hypoglycemic ferrets during prolonged surgical procedures.[7, 35] Monitor anesthesia with a pulse oximeter or a Doppler ultrasound blood pressure monitor.[35] A rectal probe may increase the usefulness of the pulse oximeter in small animals.[35]

Analgesia

Clinical signs of pain in ferrets include lethargy, anorexia, vocalization, stiff movements, reluctance to curl up in a sleeping position, and squinting.[7] Buprenorphine (0.01 to 0.03 mg/kg IV, IM, or SC q8 to 12 h) or butorphanol (0.1 to 0.5 mg/kg IM or SC q12 h) is well-tolerated by ferrets.[7, 13] Monitor carefully for signs of significant depression, hypothermia, or hyperthermia. If necessary, naloxone (0.04 mg/kg IV, IM, or SC) can be administered as a reversal agent.[7]

DIAGNOSTIC INTERPRETATION

Clinical Pathology

The PCV of ferrets is high relative to that of other species, and normal values have been reported to range from 46% to 61%.[42] The normal leukocyte range of 2.8 to 8 $\times$ 10^3, with clinically normal ferrets often having white blood cell counts of 3 to 4 $\times$ 10^3, is generally lower than that of other species.[29] There is no evidence that ferrets demonstrate a leukocytosis with stress.[7] The ferret's normal differential parallels that of the cat. Isoflurane administered for 15 minutes has been shown to result in significant decreases in hematocrit, hemoglobin, and plasma protein as well as red and white blood cell counts.[34] Coagulation profiles have not been standardized for ferrets, but the normal mean prothrombin time has been reported to be 14.4 to 16.5 seconds.[42]

In contrast to the cat and the dog, BUN values in the ferret appear to be more sensitive than creatinine in the evaluation of renal status. In cases of renal failure, BUN levels are often drastically elevated compared with relatively less significant increases in creatinine.[24, 29] However, an

elevated BUN is not specific for a renal disorder. Other significant clinicopathologic findings with renal disease in the ferret include hyperphosphatemia, hypocalcemia, hyperkalemia, and acidosis.[29]

Radiology

The cardiac silhouette of a normal ferret may appear slightly elevated from the sternum on lateral radiographs as a result of fat accumulation surrounding the ligament extending from the heart to the sternum,[6] and this finding alone should not be interpreted as a pneumothorax. Normal ferrets should have only a small amount of gas in the gastrointestinal tract.[55] Variations from this norm may indicate an obstructive pattern or ileus. The spleen is often pronounced in radiographs of even clinically normal ferrets.

EMERGENCY PROBLEMS

Cardiopulmonary Resuscitation

Cardiopulmonary resuscitation in the ferret is based on protocols published for cats. Establish an airway by intubation with a 2.0 to 4.0 mm endotracheal tube, and ventilate the ferret at a rate of 20 to 30 breaths/min taking care not to overinflate the lungs. Evaluate the cardiac rhythm with an electrocardiogram. In cases of asystole, place the ferret in lateral recumbency, and gently perform cardiac massage at a rate of 100/min. Evaluate the femoral pulse frequently. If external massage alone does not stimulate a heart beat, administer epinephrine (0.2 to 0.4 mg/kg diluted with sterile water delivered intratracheally, or 0.2 mg/kg via an intracardiac, IV, or IO route).[16] Establish an IV line, and administer fluids at a rate of 70 mL/kg/h. If mechanical systole returns but the ferret is bradycardic, administer atropine at a dose of 0.05 mg/kg intravenously or 0.10 mg/kg intratracheally.[16] Continue to monitor the electrocardiogram for treatment of specific arrhythmias.

Dyspnea

Differential diagnoses for the ferret in respiratory distress include pleural effusion (cardiac disease, neoplasia, infection, heartworm disease, hypoproteinemia, metabolic disease); pulmonary edema (cardiac disease, hypoproteinemia, metabolic disease, electrical cord bite); anterior mediastinal mass; pneumonia; pneumothorax; diaphragmatic hernia; tracheal obstruction; metabolic disease (acidosis); and profound weakness (circulatory collapse, hypoglycemia, anemia).[21, 36] Hyperthermia or pain may also manifest as dyspnea in ferrets.

The dyspneic ferret often requires oxygen supplementation before

pursuing extensive diagnostics. Evaluate the initial PCV, BG, TP, and BUN if the ferret is insufficiently stable to collect blood for an initial complete blood count (CBC) and serum chemistry. If cardiac disease is suspected, administer furosemide (see the section on cardiac disease). Obtain whole body radiographs as soon as the animal tolerates further handling. Perform thoracocentesis in cases of pronounced pleural effusion or pneumothorax, and submit fluid collected for cytology and a Gram's stain as well as culture and sensitivity if indicated.

Cardiac Disease

Cardiac disease is seen most frequently in middle- to older-aged ferrets. The most common form of cardiac disease in the ferret is dilated cardiomyopathy (DCM), with hypertrophic cardiomyopathy occurring less frequently.[54] Historical abnormalities include lethargy, anorexia, weight loss, exercise intolerance, and periods of dyspnea, tachypnea, or coughing. Tachycardia, murmurs, irregular arrhythmias, moist rales, muffled heart and lung sounds, rear limb weakness, and hypothermia are possible physical examination findings.[54] Radiographs may reveal an enlarged cardiac silhouette, pleural effusion, pulmonary edema, ascites, hepatomegaly, or splenomegaly.[54] Electrocardiography is recommended if abnormal arrhythmias are ausculted. Isoflurane anesthesia is usually needed to obtain an electrocardiogram (ECG). The ferret ECG normally contains small *P* waves but large *R* waves.[54] Echocardiography is ultimately the most informative aspect of the cardiac workup in the ferret and should be performed as soon as possible.

Use feline dosages on a per kilogram basis for cardiac drugs when uncertain of specific dosing in the ferret.[54] Furosemide for treatment of pulmonary edema is dosed at 1 to 4 mg/kg IV, SC, IM, or PO q8 to 12h.[13, 54] Although the IV route is most direct in cases of fulminant heart failure, the ferret in severe respiratory distress may only tolerate IM injection. Digoxin is used as a positive inotrope in cases of DCM or to depress AV nodal conduction of supraventricular tachyarrhythmias at a dose of 0.01 mg/kg PO q24h dosed on lean body weight (estimating a normal 15% body fat).[54] Balanced vasodilators used to decrease afterload in cases of DCM include enalapril (0.5 mg/kg PO q48h) or captopril (1/8 of a 12.5-mg tablet/ferret PO q48h).[13, 54] Monitor the ferret closely for hypotension, decreasing the frequency of dosing to once every third day if the ferret becomes lethargic.[54] Alternatively, during the initial management of heart failure, one can use a venous vasodilator such as 2% nitroglycerin ointment (1/8 in. applied to the skin or inner pinna q12 to 24h).[54] Monitor the patient for signs of hypotension. Beta-adrenergic blockers (atenolol, 6.25 mg/ferret PO q24h) or calcium channel antagonists (diltiazem, 3.75 to 7.5 mg/ferret PO q12h) are most commonly used to relax the myocardium and to improve diastolic filling in cases of hypertrophic cardiomyopathy.[13, 54]

Administer fluid therapy judiciously in ferrets with cardiac disease

to avoid fluid overload and subsequent development of pulmonary edema. Prednisone and diazoxide, medications often used to treat insulinoma, can also increase preload on the heart.[49]

Neoplasia

Lymphosarcoma (LSA) is one of the most common forms of neoplasia reported in the ferret.[2] Dyspnea can result from an anterior mediastinal mass, pleural effusion, pulmonary metastasis, or profound weakness. Mediastinal masses and pleural effusion are most common in ferrets less than 1 year of age.[17] In young animals, acute onset of clinical signs or sudden death are typical with the rapidly progressive mediastinal form of LSA.[2, 17] Other clinical signs may include anorexia, weight loss, vomiting, depression, dehydration, or signs associated with secondary infections. Accompanying physical examination findings may be referable to any body system but most commonly include hepatomegaly, splenomegaly, and lymphadenopathy.[10]

Diagnosis of mediastinal lymphoma is generally made by cytologic examination of pleural fluid. Ultrasound-guided aspiration of an anterior mediastinal mass can be used to collect samples for cytology.[15] Ferrets that have mediastinal LSA have been reported by some authors to respond favorably to chemotherapeutic protocols described in the references.[9, 10, 15]

Heartworm Disease

Infection with the canine heartworm (*Dirofilaria immitis*) is uncommon in ferrets, but the risk increases in heartworm endemic areas and when the ferret is housed outside.[25] Signs include lethargy, coughing, dyspnea, ascites, heart murmur, pulmonary congestion, or sudden death.[9, 54] The presence of even one adult worm in the small heart of a ferret can be fatal.[54]

Peripheral microfilaremia is uncommon in ferrets with dirofilariasis, so testing for the *Dirofilaria* antigen may be inconclusive.[9, 25, 54] Antibody tests used for feline patients are species specific and are not applicable to ferrets (Karen Rosenthal, MS, DVM, ABVP–Avian, personal communication, October 1997). Radiographic changes with dirofilariasis include cardiomegaly, pulmonary congestion, pleural effusion, and ascites.[9, 25] A peripheral eosinophilia may be evident on the CBC.[9] The test of choice for diagnosing dirofilariasis in ferrets is echocardiography, which images the parasite in the heart (Karen Rosenthal, MS, DVM, ABVP–Avian, personal communication, October 1997). In some cases, angiography has been used to confirm the presence of adult worms.[56] Treatment protocols have been reported, but results are inconsistent.[9, 54]

Pneumothorax

Pneumothorax can occur as a result of trauma, primary pulmonary disease, or esophageal perforation. The author has treated two ferrets with spontaneous pneumothorax.

Thoracocentesis is performed using protocols described for other small animals. If pleural air continues to accumulate, perform a tube thoracostomy. In uncommon cases of severe pneumothorax, resolution can be rapid when managed by continuous underwater suction if pressure is carefully monitored.[40] Perform diagnostics as indicated to reveal the primary pathology, and treat as indicated.

Pneumonia

Pneumonia is uncommon in ferrets and is most commonly associated with severe influenza virus or canine distemper virus (CDV) infections.[50] Coughing is not as prominent a sign of pneumonia in ferrets as in dogs.[9] Clinical signs of influenza include sneezing, epiphora, serous ocular discharge, rhinitis, anorexia, lethargy, and pyrexia.[9, 50] Influenza is usually mild and self-limiting in adult ferrets but can be fatal in neonates.[9] Because ferrets are susceptible to human influenza viruses, affected caretakers should avoid contact with ferrets. Ferrets with CDV may initially present with clinical signs similar to influenza but go on to develop a severe crusting dermatitis on the face and other areas of the body as well as marked hyperkeratosis of the footpads.[52] Ferrets that have advanced CDV infection may also present with neurologic signs.[53] Bacterial pneumonia is occasionally seen in ferrets. Pulmonary mycosis is uncommonly reported.[9, 50]

Radiographs and a CBC are often the most helpful initial diagnostic tests in cases of pneumonia.[9] A neutrophilic leukocytosis with a left shift may be pronounced.[9, 50] Radiographs demonstrate an interstitial pattern progressing to an alveolar pattern if the pneumonia worsens.[50] Aspiration pneumonia primarily involves the dependent lung lobes. If the ferret is stable, a tracheal wash to collect samples for cytology as well as bacterial and fungal cultures is important in guiding treatment. Diagnosis of CDV is generally made on the basis of clinical signs, but viral inclusion bodies may be visualized or fluorescent antibody tests performed on conjunctival or mucus membrane scrapings.[52]

Treatment for influenza consists of supportive care. Antihistamines used to control sneezing or to improve appetite include chlorpheniramine (1 to 2 mg/kg PO q8 to 12h) or diphenhydramine (0.5 to 2.0 mg/kg PO q8 to 12h).[9, 13] Use antibiotics only if a secondary bacterial infection is suspected. Euthanasia is recommended for ferrets with CDV.[9, 62] Antibiotic treatment of bacterial pneumonia is based on culture and sensitivity results. Empirical broad-spectrum antibiotics to consider while awaiting culture results include trimethoprim/sulfonamide (30 mg/kg of combined drug PO q12h), cephalexin (15 mg/kg PO q12h), or amoxicillin/

clavulanate (22 mg/kg PO q8h).[9, 13, 50] Parenteral antibiotics used with cats more rapidly achieve therapeutic blood levels in severe cases. Nebulization with gentocin may be useful in young animals.[9]

GASTROINTESTINAL EMERGENCIES

Clinical signs of gastrointestinal (GI) discomfort in ferrets are often not specific: collapse; lethargy; anorexia; dehydration; nausea evident by bruxism, ptyalism, pawing at the mouth, or frequent swallowing; retching or gagging; diarrhea; or vomiting. A number of the GI diseases affecting ferrets can have similar clinical presentations.

Profuse diarrhea can rapidly produce severe dehydration in the ferret. In contrast to the canine patient, diarrhea in the ferret is difficult to classify as being small intestinal or large intestinal in character.[26] Differential diagnoses for diarrhea include GI foreign body or trichobezoar, dietary indiscretion, *Helicobacter mustelae* gastritis, eosinophilic gastroenteritis or other inflammatory bowel disease, neoplasia, metabolic disease (i.e., hepatopathy), clostridial overgrowth subsequent to prolonged antibiotic administration, influenza, rotavirus (usually in very young, unweaned ferrets), CDV (generally accompanied by respiratory signs and a crusting dermatitis), epizootic catarrhal enteritis ("green slime disease"), GI parasitism (i.e., coccidiosis, giardiasis), and proliferative bowel disease.[21, 26, 36] Less common entities associated with diarrhea in pet ferrets include salmonellosis, Aleutian disease, and mycobacteriosis.[21, 26, 36] Frank blood in the stool may be evident with proliferative bowel disease, salmonellosis, or clostridial overgrowth.[3, 26]

Differential diagnoses for melena in the ferret include *H. mustelae* gastritis, toxin ingestion, GI foreign body or trichobezoar, hemorrhaging GI polyps, neoplasia, uremic ulceration, iatrogenic causes (i.e., nonsteroidal inflammatory drug induced), and Aleutian disease (uncommon in pet ferrets).[3, 36]

Vomiting is not as common in ferrets as in dogs or cats and must be distinguished from regurgitation.[26] The most common differential diagnoses for true vomiting in ferrets include GI foreign body, *H. mustelae* gastritis, or inflammatory gastroenteritis (including eosinophilic gastroenteritis).[25] Vomiting is not commonly seen with metabolic disease (i.e., azotemia or hepatic disease) in ferrets.[25] Regurgitation or gagging may be caused by esophageal foreign body or megaesophagus.

Initial treatment of dehydration and electrolyte imbalances is critical while pursuing diagnostics. Evaluate the PCV, BG, TP, and BUN before treatment, and submit a CBC and serum chemistry. Obtain initial survey radiographs. Additional imaging diagnostics may include ultrasonography, endoscopy, or colonoscopy. Evaluate a fecal sample wet mount and flotation as well as a fecal Gram's stain. In cases of hematochezia or if the ferret is febrile, culture the stool for *Campylobacter jejuni* or *Salmonella* spp.[26]

Gastrointestinal Foreign Body or Trichobezoar

Rubber, latex, or cloth objects are the most common GI foreign bodies in ferrets under 1 to 2 years of age, whereas trichobezoars are more common in older ferrets.[9, 26, 38] In contrast to cats, linear foreign bodies are uncommonly ingested by ferrets.[26, 38] Clinical signs of GI foreign bodies vary greatly. In cases of total gastric or intestinal obstruction, the ferret may present recumbent, dehydrated, and in circulatory collapse. In general, vomiting is an infrequent finding with GI foreign bodies in ferrets.[9, 26, 38] Diarrhea or melena may be a part of the history with trichobezoars or other foreign bodies. In some cases, gastric foreign bodies may not be totally obstructive and instead act as chronic ball valves, causing intermittent nausea, vomiting, melena, gagging, anorexia, and weight loss. Esophageal foreign bodies, though uncommon, can elicit regurgitation, gagging, or pawing at the mouth.[26]

On physical examination, the ferret may be dehydrated with tacky mucus membranes and a delayed capillary refill time. Ferrets often resist abdominal palpation or grind their teeth as a sign of GI pain, especially with small intestinal foreign bodies.[26] A gas- or fluid-dilated stomach or bowel may be palpable, and in some cases, the foreign body may be localized as well.

Radiographs are often diagnostic with abnormal findings including segmental ileus, gaseous distension of the stomach, and occasionally a visible object or trichobezoar.[26] The ferret's normal GI transit time is 3 to 4 hours.[7] Include the esophagus in the film for evaluation. Barium studies are rarely needed to confirm the diagnosis of a GI foreign body.[26] Obtain a PCV, TP, BG, and BUN as a minimum database on admission, and submit blood for a CBC and serum chemistry. With ferrets in circulatory collapse, begin fluid therapy immediately via an IV or IO catheter. Administer a broad-spectrum antibiotic with severely compromised animals or those with melena. Consider removal of a GI foreign body a surgical emergency when accompanied with signs of obstruction.[38] An esophageal foreign body, if devoid of sharp edges, may be removable with a small diameter endoscope, or alternatively, can be pushed into the stomach where it can be retrieved by way of gastrotomy.[11] If surgery is not an option in cases of suspected obstruction, fluid therapy and administration of a cat hairball remedy may facilitate passage of small objects.[25]

Helicobacter Mustelae Gastritis

H. mustelae naturally colonizes the stomach and the pyloric duodenum of many ferrets and may be clinically silent or can cause mild to severe gastritis, gastric and duodenal ulceration, and gastric adenocarcinoma.[3, 18, 19, 27, 41] Pathology may be exacerbated by environmental stress owing to environment or additional disease.[3, 27] Clinical signs include bruxism, ptyalism, abdominal pain, chronic vomiting, anorexia, weight

loss, and melena, which can cause significant anemia. While clinical disease is reported to be most common in ferrets 12 to 20 weeks of age,[3] this author has seen ferrets of all ages affected.

Assessment of the initial PCV and TP is especially important in cases of severe melena. A CBC, serum chemistry, and radiographs are part of the initial database. Once the patient is stabilized, definitive diagnosis includes biopsy of the gastric mucosa via an endoscopic or surgical approach.

Administer fluids to correct hydration. Supportive care includes parenteral nutrition in cases of severe ulcerative gastroenteritis. Treatment for *H. mustelae* gastritis has centered on a three-drug combination: amoxicillin (20 mg/kg PO q12h), metronidazole (20 mg/kg PO q12h), and bismuth subsalicylate (1 mL/kg PO q12h) administered for 3 to 4 weeks.[3, 28] A combination of omeprazole (a proton-pump inhibitor), amoxicillin, and clarithromycin has shown a notable success rate in the eradication of *Helicobacter pylori*.[28] However, omeprazole capsules supplied in timed-release form should not be opened before administration, therefore dosing is difficult in the ferret.

Epizootic Catarrhal Enteritis (Green Slime Disease)

Epizootic catarrhal enteritis (ECE) is a highly infectious diarrheal disease that affects ferrets and that can rapidly cause severe dehydration. This syndrome has been called "green slime disease" by the lay community because of the profuse green diarrhea that is its most pronounced clinical manifestation. However, green mucoid diarrhea can be seen in a variety of malabsorptive syndromes affecting ferrets and is not pathognomonic for ECE. Although the etiology of ECE has not been identified, histologic findings appear to be similar to those caused by rotavirus or coronavirus.[26]

Ferrets most commonly affected are those recently exposed to new ferrets, that is, at fairs, pet stores, or as recent additions to the household. Incubation appears to be only several days before the onset of clinical signs that may include a brief period of vomiting followed by anorexia, profuse diarrhea that often lasts from days to weeks, and subsequent pronounced dehydration. Morbidity is high, but mortality is low with the most severely affected individuals being those having underlying disease.

Diagnosis is presumptive based on the ferret's history and clinical signs. The PCV and TP may be drastically elevated due to dehydration. Profound leukopenia is generally not evident. Radiographs may demonstrate segmental ileus, which can be confused with an obstructive pattern.

Hospitalized ferrets must be isolated from other ferrets, and personnel should be made aware of possible viral transmission by fomites. Treatment consists of aggressive supportive care aimed at correcting dehydration and providing nutritional support. Antibiotic use appears

to be of little use unless indicated with accompanying disease. The author has noted significant improvement in persistent cases after administration of prednisone at anti-inflammatory doses.

Eosinophilic Gastroenteritis; Other Inflammatory Bowel Disease

Eosinophilic gastroenteritis (EGE) is an uncommon disease of ferrets generally seen in animals older than 6 months.[3] The cause is unknown, but some authors suggest an allergic or immunologic response to foods or parasites as an initiating factor.[3] Clinical signs include vomiting, diarrhea, anorexia, melena, lethargy, and weight loss. Thickened abdominal loops or enlarged mesenteric lymph nodes may be evident on palpation.

EGE is suspected when clinical signs are accompanied by a peripheral eosinophilia (equal to or greater than 1000/mm^3); however, not all cases demonstrate an abnormal differential.[9] Histopathologic demonstration of an eosinophilic infiltration of intestine, lymph node, or other tissues provides the definitive diagnosis.[9, 31]

Initiate supportive care with fluids and nutritional supplementation. Although this author has successfully treated the majority of diagnosed cases with prednisone, treatment may be unreliable because the underlying cause is unknown.[27] Adjust the dose of prednisone (0.25 to 1.0 mg/kg SQ or PO q12h) to control clinical signs.[9] Resolution of signs is most often evident within 7 days, but treatment is recommended for an additional month before tapering the dose of corticosteroid.[9] In some cases, treatment may be lifelong.

Lymphoplasmacytic gastroenteritis is a similar clinical syndrome. Histopathology provides the definitive diagnosis, and treatment is similar to that for EGE.

Neoplasia

Primary neoplasia of the GI tract is uncommon in ferrets.[26] LSA can affect any area of the ferret's digestive tract.[10, 26] Pyloric adenocarcinoma has been associated with chronic *H. mustelae*—associated gastritis in the ferret.[18] Affected animals may have clinical signs similar to those seen with a GI foreign body. Palpation and radiographs may demonstrate a fluid-distended stomach.[10, 18, 45]

Definitive diagnosis is made on biopsy, but abdominal ultrasonography may aid localization of pathology. Critical care is supportive until the animal is stable for abdominal exploratory. Surgical resection of the pyloric mass in a ferret followed by a Bilroth 1 gastroduodenostomy was reported to be successful in one case of gastric adenocarcinoma.[18] LSA involving the intestine or liver typically responds poorly to chemotherapy.[9, 10, 17]

Hepatopathy

Hepatopathies can present as acute or chronic conditions in the ferret. Differential diagnoses include hepatic lipidosis, toxin ingestion, primary or metastatic neoplasia, bacterial infection, and inflammatory disease. Other than neoplasia, primary hepatopathies appear to be rare in ferrets.[26] Hepatic lipidosis is a common result of chronic anorexia. Steroid hepatopathies are very rare, and to date, vascular shunts have not been reported in the ferret.[26] Clinical signs of hepatic disease include lethargy, anorexia, weight loss, diarrhea, vomiting, melena, anemia, and icterus (in advanced stages).[9, 26]

The most consistent diagnostic abnormality with hepatic disease is an often drastic elevation of alanine aminotransferase (ALT).[9, 29] Alkaline phosphatase may be elevated as well, and in severe cases, total bilirubin levels may increase. Abdominal ultrasound is recommended, but this author does not encourage ultrasound-guided liver biopsy, because coagulation panels, useful to assess risk of hemorrhage, have not been standardized for ferrets. Definitive diagnosis requires biopsy of the liver. Although bacterial hepatitis is not commonly reported for the ferret, in cases of persistent elevation of liver enzymes, submission of tissue for culture and sensitivity is recommended.

Institute supportive care while determining the definitive diagnosis of hepatopathy. Nutritional supplementation is important in the treatment of hepatic lipidosis. Once anorexia has resolved, hepatic lipidosis commonly requires no further treatment in the ferret. In cases of suspected bacterial hepatitis, empirical antibiotic choices pending culture and sensitivity include enrofloxacin (5 mg/kg PO q12h) or amoxicillin (20 mg/kg PO q12h) in combination with metronidazole (20 mg/kg PO q12h).[9] Administer vitamin K at the feline dosage on a per kilogram basis in cases of suspected coagulopathy. Lactulose (0.15 to 0.75 mg/kg PO q8–12h)[13] is indicated with hepatic encephalopathy. Definitive treatment of hepatic neoplasia is unrewarding unless a small portion of the liver is involved and can be resected.

Megaesophagus

Although acquired megaesophagus is a chronic condition in the ferret, complications of the disease can lead to a critical situation. The cause of megaesophagus in the ferret is unknown. Clinical signs include lethargy, anorexia, dysphagia, regurgitation, coughing or gagging, and weight loss.[26] Aspiration pneumonia is a common complication.

Diagnosis relies on history, clinical signs, and radiographic evidence of a dilated esophagus. Aerophagia or aspiration pneumonia may also be apparent on radiographs. An esophagram may delineate esophageal abnormalities, and fluoroscopy can illustrate abnormal esophageal motility.[9]

Management of megaesophagus is generally less successful in fer-

rets than in dogs, and the prognosis is very poor.[26] Motility modifiers (metoclopramide at a dose of 0.2 to 1 mg/kg PO or SC q6 to 8h, or cisapride at a dose of 0.5 mg/kg PO q8 to 24h) may be useful.[26] Treat aspiration pneumonia with protocols described in the section on cardiorespiratory emergencies.

Rectal Prolapse

Rectal prolapse is not common in ferrets but can occur in some cases of proliferative bowel disease (PBD), coccidiosis, or neoplasia.[3, 9, 10, 26] PBD, uncommonly seen in the author's practice, generally affects ferrets less than 14 months of age.[3, 9] Clinical signs, in addition to rectal prolapse, include chronic liquid or mucoid diarrhea sometimes with frank blood, tenesmus, anorexia, and cachexia. PBD may be exacerbated by environmental stress,[9] and affected ferrets may be more susceptible to other diseases.

An affected ferret may be moderately to severely dehydrated with thickened bowel loops evident on abdominal palpation. Initial diagnostics include a fecal direct wet mount and flotation, radiographs, a CBC, and serum chemistry. Definitive diagnosis is made on biopsy of intestinal mucosa.

Rectal prolapse can initially be repaired with a pursestring suture. Chloramphenicol (50 mg/kg IM, SC, or PO q12h for 14 to 21 days) is the treatment of choice for PBD.[3, 9] Resolution of the prolapse may occur spontaneously as the colon heals.[3] Coccidiosis is treated with feline protocols.

URINARY TRACT EMERGENCIES

Urethral Obstruction

Urethral obstruction most commonly affects male ferrets. Clinical signs include stranguria, lethargy, and anorexia. Male ferrets may have a palpable mass caudodorsal to the bladder.[37] Ferrets with accompanying adrenal disease may also be pruritic with bilaterally symmetrical or diffuse alopecia. In the author's experience, the most common differential diagnoses for urinary obstruction include prostatic enlargement associated with adrenocortical disease in males, urolithiasis, and cystitis. Less frequently, bladder neoplasia has also been reported as a cause of dysuria.[19]

Initial treatment for urinary obstruction is urethral catheterization. Place an indwelling catheter while determining the origin of the obstruction. If a urinary catheter cannot be passed, a 25- or 28-gauge needle can be used to perform cystocentesis as an emergency measure. Submit urine collected for urinalysis and culture and sensitivity. A cystostomy allows catheterization of the bladder directly from the body wall if passage of

a catheter via the urethra is obstructed. Submit blood for a CBC and serum chemistry. Place an IV catheter and begin fluid diuresis concentrating on correction of dehydration and electrolyte imbalances. Empirical broad-spectrum antibiotic therapy is recommended once a urine culture has been submitted and a urinary catheter placed (refer to the section on cystitis). Further diagnostics to determine the cause of the obstruction include radiographs and abdominal ultrasound. Along with ultrasonographic evaluation of the bladder, areas of special interest include the urethra, periurethral region, and adrenal glands.

Prostatic Enlargement Associated with Adrenocortical Disease

Partial or complete urethral obstruction by hypertrophied prostatic tissue accompanies some cases of adrenocortical disease in male ferrets, and prostatic disease may be the most common cause of stranguria in male ferrets over 3 years of age.[8, 47, 53] Androgens of adrenal gland origin are hypothesized to cause hyperplasia or cystic changes of prostatic tissue, which subsequently presses on the urethra.[47, 53] In some cases, prostatic tissue may become abscessed with a resultant thick purulent discharge from the prepuce.

Abdominal ultrasound may reveal unilateral or bilateral adrenomegaly, but not all cases of adrenal disease can be reliably diagnosed with this method. Although studies of adrenal gland ultrasonography in ferrets have been published,[39] diagnosis of adrenomegaly may be difficult for the ultrasonographer with little experience imaging ferrets. Elevated plasma androgen and estrogen levels have been shown to be useful in diagnosing adrenal disease in ferrets,[48, 53] but test results are often not available soon enough to be useful in an acute situation.

Removal of the diseased adrenal gland generally results in rapid dissipation of prostatic hypertrophy.[37, 53] Cystotomy may be necessary to remove accumulation of purulent material,[8] and if a prostatic abscess is involved, surgical resection of the involved tissue is recommended after a sample has been retrieved for culture and sensitivity.[9] This author maintains an indwelling urethral catheter for at least 2 to 3 days after surgery. Persistent obstruction by prostatic tissue may be a result of infection or neoplastic changes or may be stimulated by remaining abnormal adrenal tissue.[8, 53] The prognosis with prostatic abscessation may be poor because it is difficult to remove all affected tissue, and response to antibiotics is uncertain.[8, 9]

Urolithiasis

Magnesium ammonium phosphate (struvite) uroliths are the most common type of calculi reported in ferrets.[24] The incidence of struvite urolithiasis in ferrets has been less frequent with the introduction of higher-quality, animal protein-based diets that produce a more acidic urine than do plant protein-based foods.[8, 24]

Diagnosis and treatment are similar to procedures used with cats and dogs. The practitioner can treat cases of severe or persistent urolithiasis with prescrotal urethrostomy using a technique similar to that described for the dog.[37]

Cystitis

Although primary cystitis is reported to be rare in the ferret,[8, 24] purulent material in the bladder can be thick enough to cause a complete urethral obstruction.[9] What appears to be cystitis in some male ferrets may actually be discharge from a prostatic abscess.[8]

Submit a urinalysis and a urinary culture and sensitivity obtained by cystocentesis. In cases of urethral obstruction, place a urinary catheter and stabilize the ferret. Obtain radiographs and an abdominal ultrasound to evaluate the bladder, urethra, and adrenal glands.

While awaiting culture and sensitivity results, begin treatment with a broad-spectrum antibiotic: trimethoprim/sulfonamide (30 mg/kg of combined drug PO q12h), amoxicillin (20 mg/kg PO q12h), or amoxicillin/clavulanate (22 mg/kg PO q8h).[13] Severe cases of cystitis may require treatment for 2 months or longer.

Renal Failure

Clinical signs of renal failure may be nonspecific and include collapse, depression, lethargy, dehydration, anorexia, weight loss, rear limb weakness, polydipsia or polyuria, anemia, melena, oral ulcerations, or an azotemic odor to the breath.[9, 24] Differential diagnoses for renal failure in the ferret include chronic interstitial nephritis, pyelonephritis, neoplasia, toxins, and glomerulonephropathy secondary to other causes such as Aleutian disease (rarely seen in the clinical setting with pet ferrets).[24]

Diagnostics include a CBC, serum chemistries, urinalysis, urine culture and sensitivity, and radiographs. Abdominal ultrasound is helpful in evaluating renal cysts, urinary tract calculi, or abnormal renal parenchyma. An ultrasound-guided renal aspirate may yield diagnostic information.

Initial treatment consists of IV fluid support geared toward correction of dehydration and electrolyte imbalances. An active urinary sediment indicates the need for a broad-spectrum antibiotic while awaiting results of a urine culture.

ENDOCRINE EMERGENCIES

Hypoglycemia

The most common cause of hypoglycemia in pet ferrets in the United States is insulinoma (pancreatic islet cell neoplasia). Additional

differential diagnoses for hypoglycemia include anorexia or starvation, sepsis, neoplasia, hepatopathy, and other metabolic disease.[1]

Insulinoma affects ferrets ranging in age from 2 to 7 years.[12] Initial signs may be insidious and attributed by the owner to geriatric changes in their ferret.[49] The history may include episodes of collapse with hypersalivation or extreme weakness lasting from minutes to hours that typically resolve after administration of sugar-containing solutions.[43] Other common clinical signs include depression, rear limb weakness (which may be apparent as posterior paresis or ataxia), gagging, pawing at the mouth, or a dazed appearance. Occasionally severely hypoglycemic ferrets appear dyspneic. Signs are often intermittent and may not be apparent on clinical presentation. Although hypoglycemic seizures are the most common clinical sign of insulinoma in the dog, they are rare in ferrets.[12]

When a ferret over the age of 2 years presents collapsed or exhibiting any of the clinical signs described, immediately evaluate the BG level. Initial evaluation can be performed with glucose measurement strips or a digital glucometer.[43] For more accurate evaluation of BG levels, submit blood in a sodium fluoride (gray top) tube. A BG glucose level less than 70 mg/dL with accompanying clinical signs is suspicious for insulinoma, and ferrets presenting collapsed or comatose often have BG levels lower than 40 mg/dL.[9,43] An elevated serum insulin concentration (using an assay that has been validated for ferrets) concurrent with hypoglycemia is diagnostic for insulinoma.

In cases of hypoglycemic collapse, administer a slow IV bolus of 50% dextrose (0.5 to 2 mL) to response.[43] The goal of treatment is stabilization and not the complete reversal of hypoglycemia. If dextrose is administered too rapidly, the tumor will be stimulated to release large amounts of insulin, resulting in rebound hypoglycemia. Place an IV catheter and begin infusion of fluids supplemented with 5% dextrose. Control rare persistent seizures with diazepam (refer to the section on seizures). Administer prednisone (0.5 to 2 mg/kg SQ) to inhibit peripheral tissue uptake of glucose and stimulate gluconeogenesis.[43] Begin with the lowest dose needed to maintain adequate BG levels (i.e., $>$ 70 mg/dL). Continue to monitor clinical signs along with BG concentrations q12h, and increase dextrose supplementation if necessary. Once the ferret is stable, administer prednisone orally. In cases of persistent hypoglycemia, concurrently administer diazoxide, which acts to inhibit insulin release from pancreatic beta cells, beginning at the low end of the dose range (5 to 30 mg/kg PO q12h).[43] Once clinical signs have resolved, gradually discontinue dextrose supplementation while monitoring the BG level, and adjust medications accordingly. Prednisone doses can often be lowered with concurrent administration of diazoxide. Offer a meat-based, high-protein ferret or feline diet while avoiding foods high in sugar or carbohydrate.

In a minority of cases, hypoglycemic seizures or collapse may recur in spite of medications once IV dextrose supplementation is discontinued. These ferrets, once stabilized, may require surgical debulking of

the tumors to allow further management. Ongoing medical and surgical management of insulinoma is well described in the references.[9, 43, 49]

Diabetes Mellitus

Spontaneous diabetes mellitus (DM) is uncommon in ferrets.[47] Most cases of hyperglycemia develop secondary to surgery for insulinoma.[47] Clinical signs are similar to those seen in other small animals with DM.

DM is suspected when the BG concentration is consistently greater than 400 mg/dL in conjunction with glycosuria.[47] In cases of ketoacidosis, ketones are detected in the urine. A low insulin concentration concurrent with hyperglycemia confirms the diagnosis of DM.[47]

For the initial treatment of ketoacidotic DM, follow protocols used with cats to stabilize metabolic derangements. Tight regulation of BG levels in ferrets with DM can be difficult. One protocol suggests initiation of treatment with insulin when the BG level is consistently greater than 300 mg/dL.[47] Neutral protamine Hagedorn (NPH) insulin is administered at an empirical dose of 0.1 unit per ferret twice daily with serial BG concentrations to dictate dosage.[47] Once the ferret is stabilized with a BG concentration less than 200 mg/dL, treatment is continued with either NPH or Ultralente insulin (which only requires once daily dosing). The owner is instructed to use dipsticks to check for the presence of glucose and ketones in the ferret's urine. The same dose of insulin is administered if only trace amounts of glucose are present in the urine. If no glucose is detected, insulin is not administered, and if the glucose concentration is elevated, the insulin dose is increased.[47]

In cases of transient DM secondary to debulking of pancreatic tumors, hyperglycemia usually resolves within several days to 2 weeks after surgery.[9, 47] Ferrets with ongoing hyperglycemia are often very difficult to regulate.

ANEMIA

The differential diagnoses for anemia are broadly divided on the basis of regenerative versus nonregenerative processes. Differentials for regenerative anemia in ferrets include blood loss (i.e. GI bleeding, trauma, flea infestation) and hemolytic anemia potentially caused by heavy metal toxicosis or immune-mediated disease.[22] Causes of nonregenerative anemia include estrogen toxicosis of the bone marrow secondary to persistent estrus in an intact female, ovarian remnant(s), or adrenocortical disease; neoplastic infiltration of the bone marrow; or anemia of chronic disease.[22]

Immune-mediated hemolytic anemia has not been identified in ferrets owing to the lack of reagents specific for ferret antibodies.[22] Aleutian disease, an immune-mediated disease caused by a parvovirus is uncommon in pet ferrets.

Although estrogen-induced bone marrow suppression was once a serious and common cause of nonregenerative anemia involving intact female ferrets, this form of pancytopenia is rarely seen owing to the current practice of spaying females at 5 to 6 weeks of age.[22] Rarely, an ovarian remnant may secrete estrogen with similar results.[20] Increased levels of estrogen may infrequently be associated with adrenocortical disease either as a result of estradiol secretion from an adrenocortical tumor or subsequent to conversion of tumor-secreted androgens to estrogen in peripheral tissues.[48, 57] Resultant pancytopenia has been reported,[57] but this syndrome is uncommon in spite of markedly increased serum estrogen concentrations in some ferrets with adrenocortical disease.[32] Clinical signs observed with pancytopenia of any cause include petechiation, ecchymosis, GI bleeding, infection, and sepsis.

Obtain an initial PCV from the critically anemic ferret before collecting a larger volume of blood for a CBC, platelet count, reticulocyte count, and serum chemistries. Avoid anterior vena cava venipuncture in cases of suspected pancytopenia. Normal mean reticulocyte counts for female and male albino ferrets have been reported as 5.3% and 4%, respectively.[22] Pursue further diagnostics as indicated.

If the PCV is less than 15%, transfuse whole blood. If an IO catheter is used, obtain a bone marrow sample before transfusion. If an ovarian remnant is suspected, administer human chorionic gonadotropin (hCG) (100 IU per ferret) to stimulate ovulation.[24] Administration of hCG has no effect on hyperestrogenism secondary to adrenocortical disease. If the PCV remains below 15%, the prognosis is poor, and multiple transfusions along with B complex vitamins, an anabolic steroid (stanazolol, 0.5 mg/kg PO, SC q12h),[13] iron supplementation, fluid therapy, and nutritional support may be required.[9, 24] Pursue surgical treatment for adrenocortical disease, a retained ovary, or bleeding GI masses once the patient is stabilized.

VACCINE REACTIONS

Anecdotal reports of reactions following canine distemper vaccination in ferrets describe clinical signs ranging from diarrhea, gagging, vomiting, fever, or erythematous skin to circulatory collapse.[42] Although many of these reactions happen within 30 minutes after vaccination, less severe signs can be noted up to several hours later.

In cases of postvaccination collapse, administer diphenydramine hydrochloride (0.5 to 2.0 mg/kg IV or IM),[42] epinephrine (20 μg/kg IV, IM, SC, or intratracheally),[42] and a slow IV bolus of a short-acting corticosteroid (22 mg/kg of prednisolone sodium succinate or 6 to 8 mg/kg of dexamethasone sodium phosphate).[13] Administer IV fluids, and provide supportive care following treatment protocols for small animals.

SEIZURES

Seizures are uncommon in ferrets with the most common cause arguably being insulinoma-induced hypoglycemia.[1] Additional differential diagnoses include hypoglycemia from other causes; trauma; toxin ingestion; CNS infection (including rabies or canine distemper), inflammation, or neoplasia; renal failure; hepatopathy; or other metabolic derangements.[1]

Evaluate the BG level on presentation, and treat hypoglycemia as described above (refer to the section on hypoglycemia). Administer diazepam (1 to 2 mg IV to effect), and treat supportively using protocols applied to other small animals. Pursue diagnostics as indicated. Lumbar cerebrospinal fluid tap has been described in the ferret.[1]

SUMMARY

Gastrointestinal disease, neoplasia, cardiac disease, and endocrinopathy are among the most common syndromes affecting the ferret that presents in an emergency situation. Knowledge of these and other disease processes, indicated diagnostic testing, and immediate treatment protocols are critical to provide efficient and effective care to the ferret in crisis.

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Address reprint requests to

Connie J. Orcutt, DVM, ABVP–Avian
Angell Memorial Animal Hospital
350 South Huntington Avenue
Boston, MA 02130