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The ferret, *Mustela putorius furo*, has been domesticated for more than 2000 years. Its origin and early use are unclear, but historically it has been utilized for rabbit hunting and rodent control, particularly in the British Isles, Australia, and New Zealand. Ferrets have proven to be an important model in biomedical research, and much of what is known today about the ferret is based on this use. In recent years, its popularity as a household pet has risen dramatically because of its amicable nature, small size, and relative ease of housing and care. As the number of pet ferrets increase, so does the need for proper veterinary care. This chapter is written to familiarize the veterinarian with basic knowledge of ferret biology and care, medicine, and surgery.

**BIOLOGY**

The domestic ferret belongs to the order Carnivora and the family Mustelidae. Other members of this family include the weasel, stoat, otter, mink, and skunk. The ferret is most closely related to, and may be a descendent of, the European polecat, *M. putorius*, or the Steppe polecat, *M. eversmanni*. It should not be confused with the North American black-footed ferret, *M. nigripes*. The name *Mustela putorius furo* was derived from the Latin words *putor* and *furonem*, meaning “stinky thief,” and accurately describes its mischievous behavior and musky odor.

Ferrets have a long, slender body with short muscular legs, a long thin tail, small eyes, and short ears. The life span of the ferret is 5 to 8 years. They are very lively and active creatures, playing hard about 25% of the day and utilizing the remaining 75% for sleep. Ferrets are very curious and often investigate the smallest of spaces with ease, given their tubular-shaped, flexible bodies. They may be vocal at times, eliciting a chirp with excitement during play, a hiss of warning when threatened, or a scream when a painful stimulus is experienced. Ferrets normally carry themselves as they walk with their torso elevated off of the ground in a slightly hunched posture. This posture is exaggerated during play, when they distinctly arch their backs, bringing their front and rear feet closer together, and move around with a characteristic bounce.

There are several color variations that can be found in the pet trade. The most common ferret color is the sable, characterized by dark guard hairs, mask, legs, and tail, and a cream-colored undercoat. Also quite common are the albino; the black-eyed white, with a white coat and dark irises; and the cinnamon, with beige guard hair, no mask, and a cream-colored undercoat. Silver ferrets, when young, have dark gray guard hairs, an indistinct mask, and some white present on the ventrum. As they age, the coat progressively turns to a black-eyed white variation. Varieties that have white paws are considered “mitts,” and those with white heads and bibs are called “pandas.” It has been reported that breeding silver mitts together or with black-eyed whites can produce offspring with congenital abnormalities. A healthy ferret coat is shed twice a year, resulting in a long, thick winter coat and a shorter summer coat.

Ferrets measure 44 to 46 cm from nose to tail tip. Males, also known as *hobs*, are larger than females, or *jills*, with the average male weight of 1 to 2 kg and the average female weight of 0.5 to 1 kg. The weight may be less in the neutered male or greater in the spayed female. There is a seasonal fluctuation in body weight of 40% loss in the summer and gain in the winter in intact animals. Refer to Box 13-1 for additional physiologic data.
The musky odor of ferrets originates from the presence of a large number of sebaceous glands in the skin. The number of these glands increases in the breeding season in the intact animal, resulting in a stronger body odor, yellow discoloration, and oiliness of the fur. The anal glands also produce a strong, pungent odor but are rarely expressed except when frightened or traumatized. The anal glands are usually removed at an early age in the United States at the breeding facility. Ferrets are unable to sweat because of a lack of sweat glands in the skin. Overheated ferrets often flatten their bodies on a cool surface to dissipate body heat. Despite their musky odor, ferrets should be bathed no more than once or twice a month; otherwise, excessive drying of the skin and subsequent pruritus could result.

The head of the ferret is compressed dorsoventrally, elongated rostrocaudally, and lacks sutures in adults. Like the dog, the zygomatic bones of the ocular orbits are open. Ferrets have powerful jaws, large canines, and reduced molars. The mandibular teeth sit within the maxillary teeth when the jaws are closed, which allows for a shearing action when eating. Ferrets also have a large total lung capacity and respiratory reserve compared with other animals of similar size. Even more interesting is that the airways grow in length and diameter with an increase in total body length. This characteristic and the similarity of the tracheobronchial wall to that of humans makes it a good comparative model for respiratory research.

The respiratory tract of the ferret is also unique in several ways. The trachea, bifurcating at the fifth intercostal space, is quite long and large in diameter, characteristics that decrease the central airway and pulmonary resistance. Ferrets also have a large total lung capacity and respiratory reserve compared with other animals of similar size. Even more interesting is that the airways grow in length and diameter with an increase in total body length. This characteristic and the similarity of the tracheobronchial wall to that of humans makes it a good comparative model for respiratory research.

Ferrets also have a large amount of sebaceous glands in the skin, which are especially prominent near the mouth, and can be palpated. The number of these glands increases in the breeding season in the intact animal, resulting in a stronger body odor, yellow discoloration, and oiliness of the fur. The anal glands also produce a strong, pungent odor but are rarely expressed except when frightened or traumatized. The anal glands are usually removed at an early age in the United States at the breeding facility. Ferrets are unable to sweat because of a lack of sweat glands in the skin. Overheated ferrets often flatten their bodies on a cool surface to dissipate body heat. Despite their musky odor, ferrets should be bathed no more than once or twice a month; otherwise, excessive drying of the skin and subsequent pruritus could result.

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The ferret’s gastrointestinal tract differs from the dog and cat in the absence of a cecum, and that the jejunum, ileum, and ileocolic junction are not grossly identifiable. The small intestine is approximately 182 to 198 cm in length, and the large intestine approximately 10 cm. The short length of the intestinal tract results in a gastrointestinal transit time of 3 to 4 hours. The liver is large relative to body weight, making up 4.3% of the body weight in the ferret, as compared with the dog liver, which makes up 3.4% of the dog’s body weight. The ferret liver is made up of six lobes: the right lateral, the right medial, the caudate, the quadrate, the left medial, and the left lateral. The pancreas is composed of two limbs: the right, extending along the descending aspect of the duodenum, and the left, situated between the stomach and the spleen. The spleen of the ferret varies greatly in size but normally measures 5.1 cm in length, 1.8 cm in width, and 0.8 cm in thickness. It is readily palpable, and when enlarged, may extend from the left cranial abdomen across the midline and down along the right ventral abdomen caudally.

Data collected from Evans HE, An NO: Anatomy of the ferret. In Fox JG, editor: Biology and Diseases of the Ferret, ed 2, Philadelphia, 1998, Lippincott Williams and Wilkins.
The kidneys of the ferret are bean-shaped, with the right kidney sitting more cranial than the left. The adrenal glands are closely associated with their respective kidneys, both of which are typically embedded in retroperitoneal fat. The left adrenal gland lies medial to the cranial pole of the left kidney, whereas the right adrenal gland may be found under the caudal border of the caudate lobe of the liver and is closely adhered to the caudal vena cava. Accessory adrenal tissue has been found in some ferrets. This characteristic and the anatomic location of the adrenal glands make complete adrenalectomy a difficult task.

The ferret prepuce is located on the ventral abdomen. The os penis can readily be palpated caudal to the prepubic opening. Hobs also possess a prostate that is situated around the urethra adjacent to the opening of the bladder. This is important clinically, as enlargement of the prostate can restrict the flow of urine at this point. The vulva of female is located in the perineal region, ventral to the anus. In anestrous females, the vulva is only a slit-like opening, whereas hormonally active females have a swollen, fleshy vulva that may exhibit a thick, yellow vaginal discharge.

The ferret breeding season is from March to August, although artificial lighting may be used to induce year-round breeding. Female ferrets are seasonally polyestrous, induced ovulators. They typically ovulate 30 to 40 hours after copulation. Gestation lasts 41 to 42 days; if fertilization does not occur, a pseudopregnancy may last 41 to 43 days. A physiologic consequence of prolonged estrus in unbred jills is bone marrow toxicity from the chronically elevated estrogen levels.

For further detail on the anatomy of the ferret, see Evans and An.

**HUSBANDRY**

**Housing**

Ferrets may be housed singly or in groups, inside or outside of a house. When kept outdoors, however, they must be protected from extreme weather. Ferrets have difficulty tolerating temperatures above 90°F or below 20°F, and appropriate precautions must be taken to prevent their exposure to these extremes. A multilevel wire cage with smooth or wire flooring is appropriate. Glass tanks are not recommended, as they do not provide adequate ventilation. A 24" × 24" × 18" cage is a suitable sized enclosure for a ferret. A cage constructed out of a nonporous product is ideal for purposes of disinfection.

Because of their excretory habits, ferrets can be easily trained to use a litter box. This can be achieved in the cage and made readily available throughout the house when the ferret is allowed to roam free. Ferrets also enjoy a small, dark place to hide and sleep. Appropriate hide objects include a T-shirt, towel, hammock, or tent. Toys can offer great entertainment, but soft rubber or foam toys should be avoided as these objects are often the cause of foreign body obstruction. Polyvinyl chloride piping or cardboard tubes are great for play and exercise. Also, toys made of cloth, metal, hard plastic, or paper bags are safe for behavioral stimulation.

If ferrets are allowed to roam free in the house, the house should be ferret-proofed. This involves the obstruction of small places where they may escape, such as behind large appliances, inside of recliners, and within mattresses and furniture. These are often harmful places for ferrets where severe traumatic injuries may occur or soft foam might be ingested. Any other foam or rubber objects should be removed from the room as well. It is recommended that all free-roaming ferrets be supervised and suspect objects (e.g., recliners) inspected before use.

**Nutrition**

Ferrets are carnivorous and require a suitable diet. A diet that is high in good-quality animal protein and fat and low in complex carbohydrates and fiber is recommended. An adult, nonbreeding ferret has a dietary protein requirement of 30% to 40% and a fat requirement of 18% to 30%. High-quality kitten or commercially prepared ferret food can be offered in a dry pelleted ration. Commercial dog and cat food should be avoided, as these do not have adequate protein levels and often contain plant-based proteins. The ingestion of a diet consisting of plant proteins can result in urinary calculi (see Nutritional Disease). There are several good-quality, commercially prepared ferret diets available, such as Marshall Farms Premium Ferret Diet (Marshall Pet Products, Wolcott, NY), Totally Ferret (Performance Foods, Inc., Broomfield, CO), Mazuri Ferret Diet (Purina Mills, Inc., Richmond, IN, and Zupreem Premium Ferret Diet (Premium Nutritional Products, Inc., Mission, KS). Fat may be supplemented through the use of Linatone (Lambert Kay, Cranbury, NJ), a commercially available fatty acid supplement. Treats may consist of pieces of meat or meat baby food. The sick ferret can be supplemented with Prescription Diet Canine/Feline a/d (Hill’s Pet Products, Topeka, KS), Nutri-Cal (EVSCO Pharmaceuticals, Buena, NJ), or Glucerna (Abbott Laboratories, Columbus, OH), which are high-calorie, high-fat nutritional supplements. (See Therapeutics for further details on nutritional supplementation for the ill patient.) Ferrets that are prone to develop gastric hairballs can be given 1 to 2 ml of a cat laxatone 2 to 3 times a week as a prophylaxis. Water should always be made readily available. This can be accomplished via a heavy bowl or a sipper bottle. Fasting of ferrets for procedures requiring sedation or blood tests may be accomplished by withholding food for 4 to 6 hours. Extended fasts should be avoided, particularly in ferrets that have been diagnosed with insulinoma, to prevent severe hypoglycemia.

**PREVENTIVE MEDICINE**

**Routine Exams**

Owners should be educated early on about ferret preventative health care. It begins at an early age before the ferret even leaves...
the breeding farm with its initial vaccinations. It then becomes the owner’s responsibility to complete the young ferret’s early preventative health care, which consists of vaccination, heartworm prevention, and parasitic identification and treatment. These early visits to the veterinary clinic are great opportunities for veterinarians to educate owners about proper diet and husbandry. Owners should be encouraged to return annually for routine exams and subsequent vaccinations. The routine exam also creates opportunities for grooming (e.g., nail trimming) and identification and scheduling of necessary dental care. As the ferret ages, routine examination and even blood work, such as a complete blood count (CBC) and serum biochemistry panel, become important for the early detection of common, age-related diseases (e.g., insulinoma).

**Vaccination**

Ferrets are routinely immunized against canine distemper virus (CDV) and rabies virus. Ferrets are quite susceptible to CDV and there is a 100% mortality rate in unvaccinated ferrets infected with CDV.6,7 There is little information available regarding natural rabies infection in the ferret; however, experimental studies have shown ferrets to be susceptible to infection with the virus.6,9 Therefore, it is recommended to immunize them against rabies, particularly in rabies-endemic areas. As in dogs and cats, vaccination in ferrets is initiated in the presence of maternal antibodies and carried out to 14 to 16 weeks of age when maternal antibodies have waned and the ferrets’ own immune system can be stimulated to develop protective antibodies. A recommended schedule for administration of the CDV vaccine is when the ferret is 6 to 8 weeks, 10 to 12 weeks, and 14 to 16 weeks of age; the rabies vaccine should be administered at the time of the last distemper vaccination. Thereafter, annual booster vaccines for CDV and rabies are recommended. The vaccines can be administered subcutaneously in the interscapular region of the body. Some municipalities have passed ordinances requiring intramuscular administration of the rabies vaccine.

A variety of CDV vaccines have been used in ferrets, including several types of modified-live virus vaccines and recombinant canary pox-vectored vaccines, but currently there are only two USDA-approved distemper vaccines for use in ferrets.6,4,10 The first is a modified-live avian cell culture CDV vaccine, Fervac-D (United Vaccines, Inc., Madison, WI), and the other is a recombinant canary pox-vectored, subunit vaccine, Pure-vax (Merial, Duluth, GA). Canine combination vaccines or modified-live vaccines of ferret cell or low-passage canine cell origin should never be used in ferrets because of the occurrence of vaccine-induced distemper and death, particularly in sick or immunocompromised individuals.6,8

An inactivated rabies vaccine, Imrab (Rhone Mérieux Inc., Athens, GA), is licensed for use in ferrets. There are differing regulations on rabies vaccination in ferrets within city, state, and local governments, and it is advisable for the veterinarian to contact these agencies for the current policies. At this time, the American Veterinary Medical Association policy (Model Rabies Control Ordinance, http://www.avma.org/issues/policy/rabies_control.asp; March 17, 2006) for ferrets regarding vaccination, management of animals that have bitten humans, and exposure to rabid or suspect rabid animals is the same as that for dogs and cats.

Adverse reactions of the ferret to vaccination have been reported.6,11,12 Anaphylactic reactions have been documented after ferrets received the Fervac-D vaccine and the Imrab vaccine, both in combination and alone.6 Most of the ferrets experiencing an anaphylactic reaction did so after receiving the CDV vaccine, although there have been reports of reactions occurring in animals after administration of the rabies vaccine alone.6,12 Currently there are no published reports of anaphylactic reaction with the use of the Pure-vax vaccine; however, there are anecdotal reports of similar anaphylactic reactions occurring. The specific component of these vaccines or which vaccine should be implicated as the cause of anaphylactic reactions in ferrets is still unknown.

Anaphylactic reactions to vaccination generally develop within 30 minutes of the injection. Clinical signs associated with a reaction include vomiting, diarrhea, hematochezia, generalized hyperemia (most evident on the nose, mucous membranes, and footpads), hypersalivation, and fever.6,9,12 Less commonly, respiratory distress can develop. Treatment for a vaccine reaction should consist of dexamethasone (2 mg/kg SC), diphenhydramine (1 mg/kg SC or 0.5 mg/kg PO), and epinephrine (0.1 ml of a 1 : 1000 solution SC).6 Supplemental oxygen should be administered as needed for dyspnea. Because anaphylactic reactions can persist for periods up to 24 to 48 hours, prolonged monitoring is recommended, with subsequent treatment with corticosteroids, antihistamines, or epinephrine as needed.12 At the time of vaccination, owners should be advised to wait for 30 minutes after vaccination to monitor for the development of this type of reaction.

A recent report has suggested an association of the development of fibrosarcomas in ferrets with the vaccination site.21 This is the first report of such an association in an animal other than the cat. Examination of fibrosarcomas that developed at the site of vaccination in ferrets revealed similar histologic, immunohistochemical, and ultrastructural characteristics to those reported in feline vaccine-associated sarcomas.

The projected benefits of vaccination must outweigh the adverse reactions in order for them to be considered a useful tool in preventative health care. As a whole, vaccination plays a vital role in reducing the level of infectious disease transmission in a population. However, due to the occurrence of adverse reactions, recommendations for vaccination must be made on an individual basis with the animal’s age, immune status, and current health status in mind. Ferrets that have exhibited previous vaccine reactions should either receive no further CDV vaccine or receive a dose of diphenhydramine 15 minutes before vaccination, although there have been variable results with the latter option. An effective alternative CDV vaccine, which has not yet been found to elicit anaphylactic reactions, is Galaxy-D (Schering-Plough Animal Health Co., Omaha, NE), a modified-live primate cell culture CDV vaccine.2 Duration of immunity induced by this vaccine in the
ferret remains unknown, and use of Galaxy-D is extra-label in the ferret, requiring informed owner consent.

**Quarantine**

When a new ferret is brought into the household, a quarantine period is recommended before introducing it to other animals, particularly other ferrets. The purpose of the quarantine period is to identify and prevent transmission of infectious disease potentially carried by the new ferret. The duration of this period allows for the development of any clinical signs in a seemingly healthy ferret following entrance into the new household. Quarantine requires complete isolation of the ferret and its food, water, and cage supplies from other animals in the household for a period of at least 30 days. Proper hygiene such as hand washing, disinfection, and sanitation should be practiced during this period to avoid the transmission of any infectious organisms. The ferret also should receive physical and fecal examinations initially and vaccinations during quarantine. Should the new ferret exhibit any signs of sneezing, coughing, nasal or ocular discharge, fever, skin infection, diarrhea, or general unthriftiness, it should be brought to a veterinarian knowledgeable in ferret medicine immediately for a diagnostic work-up. In practice, these ferrets or any ferrets without a vaccination or medical history should be kept in strict isolation, as they can carry and transmit disease, such as canine distemper, to small animal patients. Precautions also should be made to prevent the transmission of any zoonotic disease from the ill ferret to the caretaker.

**Disinfection**

Routine disinfection in the veterinary clinic is important in preventing disease transmission and treating infection. Disinfection involves the killing of pathogenic microorganisms through physical or chemical means. Disinfectants are those chemical agents that are used on inanimate objects such as cages or feeding utensils, whereas antiseptics are those substances that may be used on living tissue for the treatment of open wounds or surgical scrub of the skin or mucous membranes. Sterilization is the complete removal of all living microorganisms from an object, an important application for instruments used for surgery or open wounds where there is a risk of infection. Techniques and agents should be chosen based on the nature and composition of the surface to be disinfected, the level of contamination and the degree of microbial killing desired, and the efficacy and safety of the disinfectant. Sterilization should be performed on all surgical instruments through physical (moist or dry heat) or chemical (glutaraldehyde, ethylene oxide, 58% hydrogen peroxide) means. When using a disinfectant, veterinarians should always follow the manufacturer’s recommendations on preparation and use to ensure efficacy and safety. Physical cleaning of any objects intended for disinfection improves the action of the disinfectant, as the killing power of disinfectants is significantly affected by the presence of organic matter. Antiseptics should be chosen based on their spectrum of action, residual effects, and tissue safety. Refer to Table 13-1 for information on commonly used antiseptics and disinfectants.

**RESTRAINT**

**Physical Restraint**

Healthy ferrets are lively and active creatures, and it is not in their nature to remain still for any prolonged period of time. Therefore, restraint of the ferret patient, either manual or chemical, is often necessary in the veterinary clinic. Restraint is also indicated for those ferrets with a tendency to bite or nip, such as young ferrets or those infrequently handled. For simple procedures, such as physical examination, grooming, and occasionally venipuncture, manual restraint is sufficient. For other procedures, such as venous catheterization or radiographs, chemical restraint is usually required.

Ferrets can be gently grasped under the thorax, allowing the caudal part of the body to rest in the opposite hand or hang freely. Fairly tractable animals can be restrained against the exam table with one hand over the neck and shoulders and the other hand over the hindquarters. With the animal in such a position, eyes, ears, nose, and skin can easily be examined, and vaccinations can be administered. More controlled restraint involves scuffing, or the grasping of the excess skin on the back of the neck, and allowing the caudal half of the body to hang freely. This technique of restraint is great for abdominal palpation. Scuffing often elicits a characteristic yawn from the ferret, aiding examination of the oral cavity or administration of oral medications. Another form of manual restraint involves supporting the length of the ferret’s body along the handler’s forearm while pressing its body snugly against the handler’s body with the head of the ferret directed behind the handler’s body. This technique allows for easy administration of injections in the rear of the ferret’s body. Alternatively, feeding the ferret a small amount of Nutri-Cal during a procedure can distract the ferret patient, aiding in restraint.

**Chemical Restraint**

When physical restraint is not sufficient to safely control the ferret for procedures, chemical immobilization can be a safe alternative. A variety of injectable drugs have been used alone or in combination for restraint or prolonged anesthesia, including ketamine, xylazine, acepromazine, medetomidine, diazepam, and Telazol (tiletamine and zolazepam; Fort Dodge Animal Health, Ft. Dodge, IA) (Table 13-2). Yohimbine and atipamizole are typically used for the reversal of sedation induced by xylazine and medetomidine, respectively. Chemical immobilization using any of these drugs should be restricted to healthy ferrets and avoided in sick and debilitated animals. Additionally, the use of any of these drugs alone is better suited for restraint to perform noninvasive procedures such as blood collection, whereas the ketamine combinations may be adequate for minor surgical procedures.

A ketamine/xylazine combination provides acceptable analgesia, muscle relaxation, duration, and a smooth recovery.
However, it is important to remember that this combination of drugs has been associated with cardiac arrhythmias and therefore should not be used in ferrets with cardiac disease. Use of the ketamine/xylazine combination also reduces certain hematologic parameters below baseline. The red blood cell count may be reduced by as much as 21%, hemoglobin concentration by 24%, hematocrit by 23%, and plasma protein by 15%. It has been suggested that these alterations may be due to sequestration of the blood in the spleen. Ketamine or Telazol may be used alone for restraint, but it is important to remember that these drugs may not lead to complete analgesia and muscle relaxation. Both of these drugs also result in hypersalivation; therefore, the use of an anticholinergic such as atropine is beneficial, particularly when these drugs are used as preanesthetic agents. A medetomidine/ketamine/butorphanol combination provides prolonged anesthetic periods with acceptable analgesia and may be effectively reversed with atipamizole.

The ideal choice for chemical immobilization in ferrets is gas inhalants. The benefit of using gas inhalants, such as isoflurane or sevoflurane, is that they are safe enough to use in healthy or sick ferrets, and the availability of these gas inhalants in most practices makes immobilization by gas anesthesia a convenient choice. Ferrets may be masked down or induced in a clear gas chamber. When utilizing either of these inhalants, the depth of anesthesia can be quickly adjusted by altering the concentration of the inspired gas. Sevoflurane has shown to provide better systolic arterial pressures and a lower heart rate than isoflurane. Additionally, isoflurane can alter hematologic parameters by decreasing the hematocrit, hemoglobin concentration, and red blood cell count by 30% to 38%, and the plasma protein by 20% to 26%, likely by the same mechanism as the ketamine/xylazine combination. More detailed information on anesthesia of the ferret may be found in the Anesthesia section of the chapter.

### TABLE 13-1 Disinfectants and Antiseptics Commonly Used to Treat Ferrets and their Environment

| Agent            | Use             | Spectrum of action                                      | Key characteristics                                                                 |
|------------------|-----------------|---------------------------------------------------------|--------------------------------------------------------------------------------------|
| **Alcohols**     | Antiseptic/     | Bactericidal                                            | Safe; used alone or in combination; physical dirt inhibits action; cytotoxic          |
|                  | disinfectant    |              |                                                        |                                                                                      |
| **Aldehydes**    | Disinfectant    | Sporicidal                                             | Poor penetration; noxious fumes                                                     |
|                  |                 |              | Organic matter slows action; good action against    | biofilms; used for sterilization of heat-labile instruments                           |
| Formaldehyde     |                 |              |                                                        |                                                                                      |
| Glutaraldehyde   |                 |              |                                                        |                                                                                      |
| **Chlorhexidine**| Antiseptic      | Bactericidal/static, limited fungicidal and limited     | Low toxicity; residual effects; unaffected by                                       |
|                  |                 | virucidal                                             | organic matter; used on skin wounds and mucous membranes; ototoxic to middle ear    |
| **Ethylene oxide**| Disinfectant    | Sporicidal                                             | Gas sterilization of heat-labile equipment;                                      |
|                  |                 |              | toxic; mutagenic; carcinogenic; ocular and mucous     | membrane irritant                                                                  |
| **Halogen**      | Disinfectant    | Bactericidal, fungicidal, virucidal                     | Sodium hypochlorite used commonly; activity                                        |
| Chlorine         |                 |              | affected by organic matter, soap, or hard water;     | inexpensive                                                                        |
| **Iodine**       | Antiseptic/     | Bactericidal, fungicidal, protozoacidal, somewhat      | Activity affected by organic matter, soap or hard                                    |
|                  | disinfectant    | virucidal and sporicidal                               | water; cytotoxic                                                                    |
| **Iodophors**    | Antiseptic      | Bactericidal                                            | Better penetration of organic matter; sustained                                      |
|                  |                 |              | release; used on skin wounds or mucous membranes;    | potential toxicity through use on                                                 |
|                  |                 |              | potential toxicity through use on large open         | wounds or in body cavities                                                          |
| **Hydrogen       | Antiseptic      | Bacteriostatic                                         | Wound irritant; cytotoxic; poor antibacterial                                        |
| peroxide         |                 |              | activity                                              |                                                                                      |
| 3%               |                 |              |                                                        |                                                                                      |
| 58%              | Disinfectant    | Sporicidal                                             | Plasma sterilization of heat-labile equipment;                                     |
| **Quaternary**   | Disinfectant    | Bacteriostatic; particularly Gram-positive              | Narrow margin of safety; high concentrations                                       |
| **ammonia**      |                 |              | can cause skin irritation or burns; activity          | affected by organic matter                                                          |
| **Compounds**    |                 |              |                                                        |                                                                                      |
| **tris-EDTA**    | Antiseptic      | Bactericidal; particularly Gram-negative               | Potentiates effects of chlorhexidine in lavage                                      |
|                  |                 |              | (Pseudomonas aeruginosa, Proteus vulgaris, Escherichia  | solutions; inexpensive; decreases the minimum                                       |
|                  |                 |              | coli, Staphylococcus aureus)                          | inhibitory concentration (MIC) for listed                                           |
|                  |                 |              | bacteria with select antibiotics in vitro             |                                                                                      |

Data from Boothe HW: Antiseptics and disinfectants, Vet Clin North Amer: Small Anim Pract 28(2):233-248, 1998.
The physical exam of the ferret should begin even before the animal is handled. Careful observation of the ferret’s mentation, posture, and ambulation can be done while taking a history from the owner. Healthy ferrets often exhibit curiosity for the new environment, actively resisting restraint to explore the new surroundings. Ferrets with underlying disease may present with decreased activity, lethargy, or may even be recumbent. Assessment of body condition can be done at this time as well, taking note of any fluctuations in body weight with each visit. When this initial assessment is completed, the ferret can be minimally restrained for a basic exam. The body temperature should be taken before the start of the exam to prevent elevated recordings from increased body heat secondary to any struggle that may occur before obtaining the reading. Ferrets readily object to insertion of a rectal thermometer and restraint will be necessary. The normal body temperature range of a ferret is between 100° F and 104° F.8

The eyes, ears, nose, and oral cavity should be the initial anatomic features examined on the ferret. Symmetry of these areas should be noted. The eyes should be checked for pupil size, lens clarity, corneal abnormalities, and palpebral function. Cataracts causing distinct lens opacities can occur in both young and old ferrets, and retinal degeneration may be the cause of abnormal pupillary light response. Examination of the ears often reveals a dark brown, waxy build-up within the external ear canals. This can be normal for the ferret; however, should wax build-up be in excess or the ferret is reported to be scratching at the ears, microscopic exam of an ear swab should be performed to check for the ear mite, Otodectes cynotis. In the United States, the major breeding farm of ferrets tattoo the ferrets when they have been neutered and descended. This can be seen as two blue dots that are located on the ventral aspect of the right pinna. The nose should be examined for discharge, and the owner questioned about the ferret sneezing. Scruffing the ferret to elicit the characteristic yawn aids in oral examination. The mucous membranes should be pink and moist with a capillary refill time less than 2 seconds, indicating adequate hydration. It is important to examine the tongue and palate for evidence of ulcers or structural defects. Identification of the existence of any dental disease is important to the overall health of the ferret, with initiation of appropriate therapy and prophylaxis. Examination of the teeth may reveal broken canines. This is usually not a problem unless the broken teeth are dark in color or causing the ferret pain, as evidenced by anorexia or a diminished appetite. Tartar accumulation on the teeth is a common problem, particularly in ferrets that are fed a soft diet, and may be accompanied by gingivitis. Ferrets with moderate to severe tartar build-up should either have their teeth cleaned with a dental scraper or be scheduled for tartar removal with an ultrasonic scaler.

Following a thorough examination of the head, it is important to palpate all lymph nodes in the ferret. Lymphosarcoma, a common neoplasia of ferrets, can cause a (generalized) lymphadenopathy that can be readily detected upon palpation. A good lymph node evaluation should begin with palpation of the cranial most lymph nodes, the submandibular lymph nodes, and progress caudally, ending with the popliteal nodes. A good lymph node evaluation should begin with palpation of the cranial most lymph nodes, the submandibular lymph nodes, and progress caudally, ending with the popliteal nodes. A good lymph node evaluation should begin with palpation of the cranial most lymph nodes, the submandibular lymph nodes, and progress caudally, ending with the popliteal nodes.

### PERFORMING A PHYSICAL EXAMINATION

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### TABLE 13-2 Dosages for Common Injectable Sedatives, Analgesics, Preanesthetics, Anesthetics, and Antagonists Used in Ferrets

| Drug                          | Dosage | Use                      |
|-------------------------------|--------|--------------------------|
| Acepromazine                  | 0.2-0.5 mg/kg SC, IM | sedative                  |
|                              | 0.1-0.25 mg/kg SC, IM | preanesthetic             |
| Atipamizole                   | 0.4 mg/kg IM         | alpha-2 antagonist        |
| Buprenorphine                 | 0.01 mg/kg SC, IM    | analgesia                 |
|Butorphanol                    | 0.05-0.1 mg/kg SC, IM| analgesia                 |
|Diazepam                      | 1-2 mg/kg IM         | sedative                  |
| Ketamine                      | 10-20 mg/kg IM       | sedative                  |
|                              | 30-60 mg/kg IM       | anesthetic                |
| Ketamine/diazepam             | 25-35 mg/kg (K), 2-3 mg/kg (D) IM | anesthetic                |
|Ketamine/medetomidine         | 5 mg/kg (K), 0.08 mg/kg (M) IM | anesthetic                |
|Ketamine/medetomidine/butorphanol | 5 mg/kg (K), 0.08 mg (M), 0.1 mg/kg (B) IM | anesthetic                |
|Ketamine/xylazine             | 20-40 mg/kg (K), 1-4 mg/kg (X) IM | anesthetic                |
|Medetomidine                   | 0.08-0.1 mg/kg IM    | sedative                  |
|Medetomidine/butorphanol      | 0.08 mg/kg (M), 0.1 mg/kg (B) IM | anesthetic                |
|Naloxane                      | 0.04-1.0 mg/kg IV, IM, SC | opioid antagonist        |
|Telazol                       | 12-22 mg/kg IM       | anesthetic at higher dosage |
|Xylazine                      | 1 mg/kg SC, IM       | sedative                  |
|Yohimbine                      | 0.5 mg/kg IM         | alpha-2 antagonist        |

Dosages acquired from Marin RP, Fox JG: Anesthesia, surgery, and biomethodology. In Fox JG, editor: Biology and Diseases of the Ferret, ed 2, Philadelphia, 1998, Lippincott Williams and Wilkins.
Palpation of the ferret abdomen can be done with relative ease and can yield important information about the patient’s condition. The ferret should be held either with one hand under the thorax or by scruffing the neck while the other hand is used to palpate the abdomen. Palpation of the j-shaped stomach in the cranial abdomen should be performed carefully in ferrets presenting for anorexia or vomiting, as pain or further trauma may be elicited in animals presenting with foreign body obstruction. Sometimes the foreign body itself may be palpable as well. The spleen can be found in the left cranial abdomen. It is often enlarged, extending caudoventrally across the abdomen with the apex along the right side of the body. Enlargement of the spleen can occur in clinically healthy ferrets, but an irregular shape or masses on the spleen are considered abnormal and should be investigated further. The intestines are palpated for the presence of gas or thickened bowel loops. The mesenteric lymph nodes are also palpated for enlargement. An attempt should be made to palpate the adrenal glands lying medial to both kidneys, particularly in ferrets presenting with signs of adrenal gland disease. Normal adrenal glands typically cannot be palpated, and in obese ferrets it may be difficult to palpate enlarged glands because of the presence of retroperitoneal fat; however, significantly enlarged adrenal glands may be detected on palpation. The bladder can be palpated in the caudal abdomen and may be painful in ferrets that have urethral obstruction and/or bladder stones. Male ferrets presenting with a distended bladder due to urethral blockage will likely require drainage of the bladder before the prostate can be assessed. An enlarged prostate may be palpated caudal to the bladder in males with adrenal disease.

In male ferrets, the prepuce should be examined for erythema or swelling that may be associated with blockage of the distal urethra. The testicles of intact males should be examined and palpated, as testicular neoplasia can occur in the hof. The vulva of jills should always be checked for swelling or discharge, a sign of estrus in intact ferrets and a sign of adrenal gland disease or remnant ovarian tissue in spayed females. The skin and coat should also be examined for abnormalities. Dermal neoplasias, such as lymphosarcoma and mast cell tumors, may be identified as small, raised plaques or nodules, multiple or single in number. Examination for fleas or other external parasites should be performed at this time. Evidence of pruritus, such as erythema or minor excoriations in the interscapular region, may be secondary to external parasites or adrenal gland disease. Ferrets that are bathed frequently may also present with dry, pruritic skin.

Alopecia that is seasonally recurring or progressing from the caudal body cranially is the most common presenting problem associated with adrenal disease. Auscultation of the heart and lungs should be done before completion of the physical exam. Labored breathing or increased respiration may be associated with primary lung disease or heart disease. The lungs should be assessed for abnormal sounds, such as harsh respiration, crackles, or wheezes, over all lung lobes. The heart can be auscultated at the level of the sixth and eighth intercostal spaces. In ferrets, the heart rate generally ranges between 180 and 250 beats per minute. The heart should be auscultated for arrhythmias, murmurs, or muffled heart sounds. Any of these can be indicative of primary heart disease, heartworm disease, or even the presence of pleural fluid. A respiratory sinus arrhythmia is common in the healthy ferret. Any ferrets with abnormal heart sounds or rhythms that are accompanied by clinical signs such as lethargy, anorexia, weight loss, or dyspnea should receive a complete cardiac work-up.

### CLINICAL TECHNIQUES AND DIAGNOSTIC TESTING

#### Venipuncture and Hematologic Testing

Venipuncture is an important clinical technique that can be done with or without sedation. There are several sites for venipuncture that may be utilized depending on the volume of blood required for testing and the availability of assistants for restraint. Blood is assumed to be 5% to 7% of the ferret’s body weight, and 10% of the ferret’s blood volume may be safely withdrawn during a single collection. Diagnostic laboratories performing hematologic tests on ferrets typically require only 0.5 to 2 ml of blood, whereas larger quantities are needed from ferrets serving as blood donors. Blood may be collected from the cephalic or lateral saphenous vein using a 25- or 26-gauge needle and 1-ml syringe when quantities of less than 1 ml of blood are required. Restraint for venipuncture of the cephalic vein is similar to that of the cat or dog, with the head of the ferret securely restrained with one hand by an assistant to prevent biting during the procedure. A towel may be wrapped several times around the body to provide additional restraint. When utilizing the lateral saphenous vein for venipuncture, an easy technique involves the use of a 25- or 26-gauge needle without an attached syringe, collecting blood drop by drop directly from the hub of the needle into capillary tubes. This is a good site when serial glucose measurements are necessary. Topical Emla cream (AstraZeneca Pharmaceuticals, Westborough, MA) can be applied on the skin over the vein to provide local anesthesia during the collection process.

Larger quantities of blood should be withdrawn from the jugular vein or anterior vena cava. Again, the ferret may be restrained like a cat for jugular venipuncture, with the forelegs pulled forward from the body and the head extended, nose pointed upward. The jugular veins of the ferret lie more laterally than the cat. Overextension of the head should be avoided as this can reduce jugular vein distention. Another technique for jugular venipuncture involves positioning the towel-wrapped ferret into dorsal recumbency with its head extended. While the ferret is distracted with Nutri-Cal, venipuncture can be performed using a 22- or 23-gauge needle bent at a 30-degree angle, attached to a 3-ml syringe. When collecting blood from the anterior vena cava, the veterinarian should consider sedating active ferrets with general anesthesia. This site should not be used in ferrets with bleedings disorders, because this vein is located within the thoracic cavity and does
not allow for direct hemostasis by the clinician. With the ferret placed in dorsal recumbency, a 22- or 23-gauge needle, attached to a 1-to-6-ml syringe, is inserted at the junction of the first rib and the sternum (Figure 13-1). If you approach from the animal’s left side, the needle should be directed toward the right elbow. If you approach from the animal’s right side, the needle should be inserted parallel to the sternum. The anterior vena cava is superficial within the thoracic cavity and may often be located upon retraction of the needle. Always maintain a negative pressure draw, looking for a blood “flash” in the hub of the needle.

Diagnostic laboratories usually establish reference ranges for the tests offered for ferrets. Reference ranges for the ferret CBC and serum chemistry panel may be found in Box 13-3 and Table 13-3, respectively. Hematologic parameters for the ferret are very similar to those of the cat; however, the erythrocyte, hematocrit, and reticulocyte counts are generally higher in the ferret. Ferrets also have a slower erythrocyte sedimentation rate; therefore, it is necessary to spin microhematocrit tubes for longer time periods than for dogs or cats. There is little information available on blood coagulation parameters in ferrets, although the prothrombin time has been reported to be 14.4 to 16.5 seconds. As with other animals, there is an age-related decrease in the enzyme alkaline phosphatase due to

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**Figure 13-1** With the anesthetized ferret in dorsal recumbency, the anterior vena cava can safely be sampled.

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**BOX 13-3** Hematologic Values for the Ferret*

| Value                  | Female | Male |
|------------------------|--------|------|
| PCV (%)<sup>18-20</sup> | 34.6-55| 33.6-61|
| Hemoglobin (g/dL)<sup>18-20</sup> | 11.9-17.4 | 12-18.5 |
| Erythrocytes (<x10<sup>12</sup>/mm<sup>3</sup>)<sup>18,19</sup> | 6.77-9.76 | 7.1-13.2 |
| Reticulocytes (%)<sup>18,19</sup> | 2-14 | 1-12 |
| Platelets (<x10<sup>12</sup>/mm<sup>3</sup>)<sup>18,19</sup> | 264-910 | 297-730 |
| MCV (fL)<sup>18</sup> | 44.5-53.7 | 42.6-52.5 |
| MCH (pg)<sup>18</sup> | 16.4-19.4 | 13.7-19.7 |
| MCHC (g/dL)<sup>18</sup> | 32.2-42.2 | 30.3-34.9 |
| Leukocytes (<x10<sup>9</sup>/mm<sup>3</sup>)<sup>18-20</sup> | 2.5-18.2 | 1.7-19.1 |
| Neutrophils (%)<sup>18,20</sup> | 12-84 | 11-82 |
| Bands (%)<sup>18,20</sup> | 0-4.2 | 0-2.2 |
| Lymphocytes (%)<sup>18,20</sup> | 12-95 | 12-73 |
| Monocytes (%)<sup>18,20</sup> | 1-8 | 0-9 |
| Eosinophils (%)<sup>18,20</sup> | 0-9 | 0-8.5 |
| Basophils (%)<sup>18,20</sup> | 0-2.9 | 0-2.7 |

*Combined values for adult female ferrets and for adult intact and castrated males from Fox JG: Normal clinical and biologic parameters. In Fox JG, editor: Biology and Diseases of the Ferret, ed 2, Philadelphia, 1998, Lippincott Williams and Wilkins; Thornton PC, Wright PA, Sacra PJ et al: The ferret, Mustela putorius furo, as a new species in toxicology, Lab Anim 13:119-124, 1979; and Lee EJ, Moore WE, Fryer HC et al: Hematological and serum chemistry profiles of ferrets (Mustela putorius furo), Lab Anim 16:133-136, 1982.

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**TABLE 13-3** Serum Biochemical Values for the Ferret*

| Value                  | Female | Male |
|------------------------|--------|------|
| Sodium (mmol/L)<sup>18-20</sup> | 142-156 | 137-162 |
| Potassium (mmol/L)<sup>18,20</sup> | 4.2-7.7 | 4.1-7.3 |
| Chloride (mmol/L)<sup>18,20</sup> | 112-124 | 102-126 |
| Calcium (mg/dL)<sup>18,20</sup> | 8-10.2 | 8.3-11.8 |
| Phosphorus (mg/dL)<sup>8-20</sup> | 4.2-10.1 | 4-8.7 |
| Glucose (mg/dL)<sup>18-20</sup> | 85-207 | 62.5-198 |
| Urea nitrogen (mg/dL)<sup>18-20</sup> | 10-45 | 11-42 |
| Creatinine (mg/L)<sup>18,20</sup> | 0-1 | 0.2-1.6 |
| Protein (g/dL)<sup>18,20</sup> | 5.1-7.2 | 5.3-7.4 |
| Albumin (g/dL)<sup>18-20</sup> | 2.5-4.1 | 2.8-4.2 |
| Globulin (g/dL)<sup>18</sup> | 2.2-3.2 | 2.0-4.0 |
| A/G ratio (g/dL)<sup>18</sup> | 1.0-1.6 | 0.8-2.1 |
| Total bilirubin (mg/dL)<sup>18,19</sup> | 0-1.0 | 0.0-0.1 |
| Cholesterol (mg/dL)<sup>18,19</sup> | 122-296 | 64-221 |
| Alkaline phosphotase (U/L)<sup>18-20</sup> | 3-62 | 11-120 |
| Aspartate aminotransferase (U/L)<sup>18,19</sup> | 40-120 | 28-248 |
| Alanine aminotransferase (U/L)<sup>18,20</sup> | 54-280 | 54-289 |
| Carbon dioxide (mmol/L)<sup>18,20</sup> | 16.5-27.8 | 12.2-28 |

*Combined values for female ferrets and intact and castrated male ferrets from Fox JG: Normal clinical and biologic parameters. In Fox JG, editor: Biology and Diseases of the Ferret, ed 2, Philadelphia, 1998, Lippincott Williams and Wilkins; Thornton PC, Wright PA, Sacra PJ et al: The ferret, Mustela putorius furo, as a new species in toxicology, Lab Anim 13:119-124, 1979; and Lee EJ, Moore WE, Fryer HC et al: Hematological and serum chemistry profiles of ferrets (Mustela putorius furo), Lab Anim 16:133-136, 1982.*
a reduction in the bone isozyme when rapid growth has ceased.\textsuperscript{19} Differential diagnoses for ferret patients that present with elevated liver enzymes include liver disease, exposure to ingested or environmental toxins, and Aleutian disease.\textsuperscript{19} Creatinine is normally cleared from the blood much faster in ferrets than other mammalian species; thus, any elevation in creatinine is significant and should be pursued further.\textsuperscript{20}

### Urine Collection and Urinalysis

Urinalysis is useful for identifying urinary tract disease in the ferret. Urine can be collected from a voided sample, urethral catheter, or cystocentesis. When evaluating voided or catheterized samples, bacterial contamination is a possible complicating factor to consider. Although sometimes necessary in the blocked patient, catheterization, particularly in male ferrets, can be difficult. Samples acquired via cystocentesis are preferred, and in obstructed ferrets, where catheterization cannot be achieved, cystocentesis is necessary for immediate relief of a significantly distended bladder. With the ferret under anesthesia and positioned in lateral or dorsal recumbency, the bladder should be isolated between your index finger and thumb and the sample collected using a 22- to 25-gauge needle fastened to a 3- to 6-ml syringe; this is similar to the technique used for dogs and cats. Metabolism cages may also be used to collect 24-hour urine samples.

Catheterization of the ferret usually requires general anesthesia. Sterile technique is recommended to prevent the iatrogenic introduction of contaminants into the urinary tract. Again, male ferrets can be difficult to catheterize; this is because of the acute angle at which the urethra turns at the ischial arch. The presence of a urethral stone or prostatomegaly may make the procedure impossible without causing additional trauma. Care should be taken to prevent iatrogenic perforation of the urethra when passing the catheter through this turn at the ischial arch. With the ferret placed in dorsal recumbency, the penis is extracted from the prepuce, initiating the catheterization process. Magnification may be necessary to visualize the urethral opening on the ventral aspect of the penis. A needle with the bevel filed off can be inserted into the opening to flush and distend the urethra with saline to facilitate the introduction of the catheter into the urethra. A water-soluble lubricant also makes passage of the catheter easier. A 20- to 22-gauge, 8-inch jugular catheter, a 3.5-Fr red rubber tube, or a 3.0-Fr Slippery Sam Tomcat urethral catheter (Cook Veterinary Products, Eight Mile Plains, Queensland, Australia) may be used.\textsuperscript{21} The latter option is preferred based on the size and rigidity of the catheter. An intravenous catheter stylet or sterile guitar string can be used to provide rigidity to the catheter; again, the veterinarian needs to be conscious not to traumatize the urethra during the passage of the catheter.\textsuperscript{21}

Female catheterization is an easier technique. With the animal under general anesthesia, the female should be placed in ventral recumbency with the caudal body elevated. The urethral opening is located on the ventral floor of the vaginal vestibule, just cranial to the clitoral fossa. It may be visualized with an otoscope, endoscope, or a vaginal speculum. The catheter can be placed by sliding it along the ventral floor of the vestibule, just cranial to the clitoral fossa. It may be visualized with an otoscope, endoscope, or a vaginal speculum. The catheter can be placed by sliding it along the ventral floor of the

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### Table 13-4 Normal Urinalysis Parameters for the Ferret

| Parameter                  | Males         | Females       |
|----------------------------|---------------|---------------|
| Volume (ml/24 hr)          | 8-48          | 8-140         |
| pH                         | 6.5-7.5       | 6.5-7.5       |
| Protein (mg/dl)            | 7-33          | 0-32          |
| Potassium (mmol/24 hr)     | 1.0-9.6       | 0.9-5.4       |
| Sodium (mmol/24 hr)        | 0.4-6.7       | 0.2-5.6       |
| Chloride (mmol/24 hr)      | 0.7-8.5       | 0.3-7.8       |

Data collected from Fox JG: Normal clinical and biologic parameters. In Fox JG, editor: Biology and Diseases of the Ferret, ed 2, Philadelphia, 1998, Lippincott Williams and Wilkins.

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vagina, directed at an acute angle ventrally, until it enters the urethra.\textsuperscript{21,22} Catheters that are placed for therapeutic purposes can be secured by suturing butterfly tape to the skin, and if necessary, catheters can be attached to a urine collection system. Ferrets should be closely monitored for entanglement of the tubing or disturbance of the catheter set.

- Normal ferret urinalysis parameters can be found in Table 13-4. Protein is a common finding in ferrets, possibly due to high systolic pressure and thicker intrarenal arterial walls.\textsuperscript{18} With this finding, however, the clinician should include genitourinary infection and Aleutian disease as differential diagnoses. Blood in the urine may be the result of iatrogenic trauma to the urethra during catheterization, cystitis, urethritis in males, or estrus in females. False positives for ketonuria in male ferrets have been reported with the use of urinalysis strips. The similarity in color of the dark urine produced by male ferrets and the reagent test strip is a possible explanation of the ketonuria false positive result.\textsuperscript{17} Examination of urine sediment may reveal crystalluria in patients with blocked urethras or an accumulation of white blood cells in ferrets with urinary tract infection (Figure 13-2). An elevated urine pH has been associated with a diet high in plant proteins and is a good indication that diet correction may prevent crystalluria and subsequent urolithiasis.

### Fecal Examination

Although intestinal parasitism is relatively uncommon in captive ferrets, the examination of feces as a diagnostic tool should not be overlooked considering the susceptibility of the ferret to a variety of gastrointestinal (GI) disorders. Due to the short GI transit times and the habit of ferrets to defecate in the same location within their cages, acquisition of a sample is not difficult. Often, restraint in the exam room is enough to stimulate defecation by the ferret patient. The color, quantity, and consistency of the fecal sample should be described in the record, as this may change according to the disease process present (e.g., green, mucoid diarrhea associated with green slime disease). Fecal exams for parasite identification may be performed at the time of the annual exam using a direct smear and a fecal flotation technique with sodium nitrate or a sugar solution. Further discussion of internal parasitism can be found in the section on infectious diseases. Ferrets that present with diarrhea should also have a fecal Gram stain done to evaluate
the sample for the presence of pathogenic microorganisms. If bacterial pathogens are suspected, a fecal culture should be pursued.

**Diagnostic Imaging**

Diagnostic imaging is very useful in the assessment of several disease processes in ferrets. Radiography is advantageous in the initial identification and assessment of common diseases, such as cardiac disease, splenomegaly, GI disease, urolithiasis, and prostatomegaly. Where questions may be left unanswered regarding GI disease through survey radiographs, the addition of contrast material becomes useful for the diagnosis of foreign body obstruction, bowel loop thickening, or even gastric ulceration. Ultrasonography has also proven useful in the further evaluation of certain disease processes such as cardiac disease, renal cysts, and adrenal gland disease.

Because radiographic techniques require an immobile patient, sedation is usually necessary. Ferrets’ long cylindrical bodies can make proper positioning for radiography challenging, but extension of the forelimbs cranially alongside the head and the rear legs caudally facilitate this endeavor. They can then be secured in place with medical tape for film exposure. The entire body of most ferret patients can fit on a large cassette film, reducing the number of radiographs required for many examinations. The radiographic settings preferred for all full body ferret radiographs are 50 kVp, 100 mAs, and 1/10 sec time. For contrast radiography, 4 to 6 ml of barium is the recommended oral contrast dosage. If gastric ulcers or a bowel perforation is suspected, an iodine-based contrast is recommended. Ferrets have a rapid GI transit time; therefore, films should be taken every half-hour to gain a complete assessment of the GI tract.

Ultrasonography in the ferret follows the same principles applied to the cat and dog. Although ultrasonography does not require sedation, a technique of distraction (e.g., Nutri-Cal treat) usually reduces any active resistance. A higher frequency transducer, such as a 10- or 11-MHz transducer, is recommended to enhance the resolution of the image for the smaller ferret patient.

**Cytology and Microbiology**

The use of cytology and microbiology as diagnostic tools can greatly improve the clinician’s ability to identify and treat various ferret diseases. Impression smears or fine needle aspirates of masses or enlarged lymph nodes can aid in the identification of neoplastic disease, such as lymphosarcoma, before further work-up with biopsy and histopathology. Bone marrow aspiration and cytology are particularly useful in cases of anemia, thrombocytopenia, pancytopenia, and possible hematopoietic neoplasia (see Surgery). Obtaining culture and sensitivity results of any discharges, abscesses, or nonhealing lesions is very important for identifying a source of infection and the drugs that will provide the most effective treatment. Additionally, a Gram stain may be used to direct a clinician toward an appropriate antibiotic with which to initiate therapy until more definitive results are received.

**Serology and Miscellaneous Tests**

Serology can assist in the diagnosis of several important infectious disease processes in ferrets. The choice of serologic test is made based on a patient’s possible exposure to infectious disease and the presence of associated clinical signs. Canine distemper virus can be tested by a fluorescent antibody test that is performed on conjunctival smears or scrapings, mucous membrane scrapings, or blood smears. This test identifies CDV antigen within cells, but is only useful in the early stages of infection, and false negatives are possible. Influenza virus, another respiratory pathogen of ferrets, may be diagnosed serologically using an enzyme-linked immunosorbent assay (ELISA). This test detects antibodies to the virus and may be an option for rapid diagnosis. Aleutian disease, a wasting disease of ferrets caused by a parvovirus, can be diagnosed by the demonstration of antibody titers to the disease as well as
a hypergammaglobulinemia through serum protein electrophoresis. There are two serologic tests used to diagnose Aleutian disease in ferrets: a counterimmunoelectrophoresis, with high specificity, and an immunofluorescent antibody test, having increased sensitivity. Counterimmunoelectrophoresis, a screening test for the same disease in mink, also has the advantage of being rapid and inexpensive. Finally, ELISA tests used to detect the presence of heartworm antigen in dogs and cats can also be used to diagnose heartworm disease in ferrets (refer to Heartworm Disease for specific information).

**COMMON DISEASE PRESENTATIONS**

Ferrets are susceptible to many disease processes; some are diagnosed and treated similar to dogs or cats, whereas others are unique to the ferret. The preceding clinical techniques were provided as a guide to the practitioner in understanding and diagnosing these diseases. The following information will familiarize the clinician with specific ferret disease processes that are very common or limited to this species.

**Infectious Disease**

**BACTERIAL DISEASE**

**Helicobacter Gastritis**

There are several animal species that are affected by the gastric, spiral bacterium, *Helicobacter* spp., and ferrets are among those susceptible. Approximately 100% of ferrets in North America acquire *Helicobacter mustelae* at, or shortly after, weaning. Ferrets have become important models for human infection of *Helicobacter pylori*. This bacterium colonizes the gastric mucosa and can cause gastritis and peptic ulcers. It has also been associated with gastric adenocarcinoma and mucosa-associated lymphoid tissue lymphoma.

Not all ferrets show clinical signs, despite the pathogenicity of this organism.

Ferrets younger than 2 years of age, or older ferrets that are stressed due to diet change or the presence of concurrent disease, are most likely to exhibit clinical signs of *Helicobacter gastritis*. Clinical signs include bruxism, ptyalism, blood-tinted vomiting, diarrhea, melena, and chronic weight loss. Other common diseases that should be included as differential diagnoses for these clinical signs listed include foreign body obstruction, eosinophilic gastroenteritis, and proliferative bowel disease. A CBC may identify dehydration evidenced by an increased hematocrit or regenerative anemia from blood loss due to gastric ulcers. The identification of blood in the stool through a fecal occult blood test can also support a diagnosis of gastric ulceration. A positive diagnosis of this disease requires special media and culture techniques. Endoscopic biopsy may be utilized to acquire the necessary tissue sample to allow for the histologic demonstration of *H. mustelae* with the Warthin-Starry stain.

Several therapeutic regimens exist for the treatment of *Helicobacter* spp. gastritis that use combinations of antibiotics, mucosal protectants, proton pump inhibitors, and H₂ receptor antagonists (Table 13-5). Some of the therapeutic agents may be compounded to formulate a suspension that is not only easier to administer but more palatable through the addition of artificial flavorings. Metronidazole is best compounded to a 50-mg/ml meat-flavored suspension because of the drug’s naturally bitter taste. During the initial stages of treatment, supportive care should not be overlooked. Fluids for the dehydrated patient and a highly palatable, easily digested diet such as Hill’s Prescription Diet Canine/Feline a/d or Glucerna should be administered until the ferret regains its appetite. All of the listed regimens require long-term treatment of 3 to 4 weeks for complete recovery. Unfortunately, prior infection does not induce protection, and patients may become reinfected.

**Proliferative Bowel Disease**

Proliferative bowel disease (PBD) is a GI disease that affects young ferrets, typically less than a year of age. *Desulfovibrio* sp., an intracellular *Campylobacter*-like organism, is the causative agent of ferret PBD and infects the ileum, the colon, or both. *Desulfovibrio* sp. is closely related to, or is the same organism as, *Lawsonia intracellularis*, the etiologic agent of swine proliferative enteropathy. Acute signs of this disease include colitis, diarrhea with flecks of blood, anorexia, and weight loss. Chronically affected ferrets may exhibit chronic diarrhea, tenesmus, and rectal prolapse. Neurologic signs, such as head tilt, ataxia, or tremors, may even be present in some cases. On examination of a ferret with PBD, palpation of the abdomen may reveal a segmentally thickened colon and enlarged mesenteric lymph nodes. Other causes of GI disease should be ruled out; however, a presumptive diagnosis may be made based on history, clinical signs, and physical exam. PBD can be confirmed by histopathologic tests of tissue biopsies obtained from intestines or colon. The organism is identified using the Warthin-Starry stain and appears as comma-shaped organisms located in the apical regions of intestinal epithelial

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**TABLE 13-5 Treatment Combinations for Helicobacter Gastritis**

| Drug Combination | Dosage | Route |
|------------------|--------|-------|
| **Combination 1** |        |       |
| clarithromycin   | 25 mg/kg, BID | PO |
| omeprazole       | 0.7 mg/kg, SID | PO |
| metronidazole    | 75 mg/kg, SID | PO |
| **Combination 2** |        |       |
| amoxicillin      | 30 mg/kg, BID | PO |
| metronidazole    | 20 mg/kg, BID | PO |
| bismuth subsalicylate | 17.5 mg/kg, TID | PO |
| cimetidine       | 10 mg/kg, TID | PO |
| **Combination 3** |        |       |
| enrofloxacin     | 8.5 mg/kg/day, divided twice | PO |
| colloidal bismuth subcitrate | 12 mg/kg/day, divided twice | PO |

*These drugs may be added preferentially by the practitioner.*

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Note: The above information is a summary of the processes and conditions associated with ferret disease, with a focus on infectious diseases, particularly Helicobacter gastritis. The table lists specific treatment combinations for Helicobacter gastritis, emphasizing the importance of supportive care and long-term treatment. The text outlines the pathogenesis, clinical presentation, and treatment regimens for ferret disease processes, highlighting the significance of Helicobacter gastritis and Proliferative Bowel Disease as examples of infectious and proliferative GI disorders in ferrets.
cells. The preferred treatment is chloramphenicol, orally, subcutaneously, or intramuscularly at 50 mg/kg every 12 hours for 2 to 3 weeks. If present, a rectal prolapse typically resolves with the antibiotic treatment, rarely requiring the application of a purse-string suture. When treated early in the disease process, most ferrets respond well; however, there are ferrets that do not survive despite implementation of the recommended treatment and supportive care.

**Bacterial Pneumonia**

Bacterial pneumonia is a common sequela to meg aesophagus or to a primary viral disease (e.g., influenza). Primary bacterial pathogens include *Streptococcus zoopneumoniae, Staphylococcus pneumoniae*, and groups C and D *Streptococcus*. Other pulmonary bacterial pathogens found in ferrets include *Bordetella bronchioltica*, *Listeria monocytogenes*, *E. coli*, *Pseudomonas aeruginosa*, and *Klebsiella pneumoniae*. Overt clinical signs include labored breathing, cyanotic mucous membranes, nasal discharge, and fever. Harsh lung sounds, wheezes, or crackles may be heard on auscultation. A CBC often reveals a leukocytosis characterized by a neutrophilia with a left shift. An interstitial or alveolar pattern may be evident on radiographs. When aspiration pneumonia is present, the dependent lung lobes show evidence of change on radiographs, whereas primary airway disease produces a bronchial pattern. The most helpful diagnostic approach is a cytologic examination and culture of material obtained through a tracheal or lung wash. Cytologic examination typically reveals a septic inflammatory process characterized by degenerative neutrophils. The culture and sensitivity are important to ensure appropriate antibiotic selection. Until the clinician receives these results, initiation of a broad-spectrum antibiotic treatment regimen is warranted. Supportive care, including fluid therapy and nutritional support, is important in promoting the recovery of ferrets diagnosed with bacterial pneumonia.

**Miscellaneous Bacterial Infections**

Additional bacterial diseases of ferrets include abscesses, pyoderma, or urinary tract infections. For any disease presentation with a suspected bacterial etiology, a culture and sensitivity of the infection site are always recommended. If the bacterial infection is secondary to other disease processes, the primary disease should be identified and treated to prevent recurrence of the concurrent bacterial infection.

**VIRAL DISEASE**

**Canine Distemper**

Canine distemper is a highly fatal disease in ferrets, with a mortality rate of almost 100%. Unfortunately, due to vaccination, preventative health, and client education, the disease is relatively uncommon. Canine distemper is caused by a large, single-stranded RNA virus of the genus *Morbillivirus* and the family Paramyxoviridae. It is transmitted by aerosol exposure of infected body fluids and by direct contact with infected animals and contaminated fomites. Canine distemper virus (CDV) is shed in conjunctival, nasal, and oral exudates, urine, feces, and skin dander. Transplacental transmission does not occur in the ferret. Unvaccinated dogs and wildlife species (raccoons, mink, coyotes) are considered reservoirs of the virus.

Viremia may be detected 2 days postinfection and persists until neutralized by antibodies or death of the ferret. The primary site of viral replication is within the respiratory epithelium and lymphoid tissue. Replication may occur in the liver, kidney, gastrointestinal tract, bladder, and brain, following dissemination through peripheral blood leukocytes.

CDV is characterized by two classic phases of the disease. The first and most common is the cattarrhal phase, which occurs 7 to 10 days postinfection. This phase of the disease is characterized by anorexia, pyrexia, photosensitivity, and a serous nasal discharge. A fever will spike 3 to 5 days postinfection and last for several days. Also characteristic is an orange-tinted rash of the chin and inguinal areas. As the disease progresses, the nasoocular exudate becomes mucopurulent, and a brown, crusted material accumulates around the eyes, lips, and nose. With the accumulation of this encrusted material and dehydration of the patient, the eyelids may become adhered. Hyperkeratosis of the footpads is an inconsistent clinical sign and may be difficult to appreciate, due to the small size of the ferret footpad. Untreated cases may also develop a secondary bacterial pneumonia or other secondary disease processes. Melena may be observed early on, secondary to the stress of the disease process. Before death, the ferret’s body temperature drops to a subnormal temperature. If the patient survives the cattarrhal phase of CDV, a neurotropic phase will develop. This phase of the disease is characterized by hyperexcitability, excess salivation, muscle tremors, convulsions, and coma.

A presumptive diagnosis may be made on the basis of a questionable vaccination history, clinical signs, and exposure to a potential source of CDV. Early in the course of the disease, with the presence of respiratory signs, influenza should be included as a differential diagnosis, whereas in the neurotropic phase of the disease, rabies must be a disease consideration for the patient. Diagnostic tests only lend support to a presumptive diagnosis of CDV infection, revealing a leukopenia on CBC and lung consolidation or congestion on radiographs. The diagnostic test of choice to confirm the antemortem diagnosis is the fluorescent antibody test on a peripheral blood smear, buffy coat, or conjunctival scraping. Unfortunately, the fluorescent antibody test is most useful in the first few days of infection and becomes less sensitive as the disease progresses. Gross pathology is usually limited to nasoocular exudate, dermatitis, hyperkeratosis, and occasionally splenomegaly, pulmonic congestion, and consolidation. Histologically, intracytoplasmic and possibly intranuclear inclusion bodies are present in the respiratory epithelial cells and bladder transitional epithelium. Fluorescent antibody staining of tissues can be used to confirm the diagnosis.

Ferrets with CDV infection have a grave prognosis. These patients should be isolated from other ferrets, monitored closely, and provided aggressive supportive care consisting of antibiotics, fluids, and force-feeding. There is no specific treat-
ment for CDV. Prevention of infection or significant disease is accomplished through annual vaccination. Transmission and exposure can also be reduced through proper disinfection and quarantine. CDV is relatively labile and can be cleared from the environment using heat, drying, detergents, and common disinfectants.24,34

**Influenza**

Human influenza virus types A and B of the class Orthomyxoviridae infect ferrets, causing a respiratory disease similar to that of humans.34 Ferrets are commonly used as animal models for flu research in humans because of this similar biologic response. In nature there are a number of influenza strains, exhibiting variable virulence.25 The disease is generally mild in adults, characterized by upper respiratory signs, but is potentially fatal to very young kits.24,34 Transmission of the virus occurs from human to ferret and ferret to human through aerosolization. Ferrets can transmit the virus at the height of the febrile state for 3 to 4 days.24 The disease is commonly diagnosed in ferrets after the owner experiences a similar illness.

Influenza virus localizes in the nasal epithelium but may descend to cause pneumonia, which is a common problem in kits.26,34 Clinical signs appear 48 hours after infection and include anorexia, malaise, pyrexia, sneezing, and a serious nasal discharge. Experimental infection has produced a biphasic febrile response and an increase in hemagglutination inhibiting (HI) antibodies.28 The virus and antibodies can be found in the nasal secretions of the infected animal.

Diagnosis is based on history, clinical signs, and recovery in 4 to 5 days.25 Rarely is viral isolation or HI antibody titer necessary to obtain a diagnosis. There is an ELISA diagnostic test available for rapid diagnosis of influenza A infection in ferrets.29 Once a diagnosis of influenza is made, supportive therapy in the form of fluids and antibiotics should be implemented to treat the dehydrated patient and prevent secondary bacterial pneumonia. If needed, a pediatric cough suppressant (without alcohol) can be given at the pediatric dose on a per weight basis. Experimentally, the antiviral drug amantadine, at 6 mg/kg as an aerosol every 12 hours, has shown good results for treatment of the viral infection.24 Drugs utilized to reduce pyrexia have shown variable results, as lowering the fever has been associated with higher viral shedding and a slower decrease in virus levels of the infected patient.24 There is no vaccination; however, natural infection induces protective immunity that can last for at least 5 weeks postinfection.34

**Epizootic Catarrhal Enteritis**

Epizootic catarrhal enteritis is caused by a coronavirus and is characterized by an intestinal disease that is seen in resident ferrets 2 to 3 days after exposure to an infected ferret.28 Older ferrets are most susceptible, whereas younger ferrets may be asymptomatic or present with only mild disease.28,34 Transmission most likely occurs via direct contact or fecal/oral exposure. Infected ferrets exhibit a characteristic profuse, mucoid, green diarrhea from which this disease has obtained the nickname “green slime disease.” Ferrets may also show signs of lethargy, dehydration, and anorexia. A CBC is usually within normal limits, unless changes are present due to dehydration. Serum chemistry panel changes may include elevations in the liver enzymes, ALP and ALT, and elevations in BUN and glucose.28,31 Morbidity may be high; however, with treatment, mortality may be kept to a minimum. Treatment is focused primarily on maintaining hydration while the immune system eliminates infection. Fluids can be administered via the subcutaneous, intravenous, or intraosseous route, depending on the severity of dehydration. Fluid volume should be calculated based on the fluid deficit and the daily fluid requirement of 75 to 100 ml/kg/day. Additional supportive therapy should consist of antibiotics to prevent secondary bacterial infection during the course of disease, as well as a critical care diet for nutritional supplementation. Ferrets with epizootic catarrhal enteritis should be kept in strict isolation from other ferrets, and proper disinfection of cages and cage items (food bowls, toys, litter pans) should be performed to prevent spread of the virus.

**Aleutian Disease**

The incidence of Aleutian disease has increased in recent years. It is a chronic progressive disease, caused by a parvovirus, first identified in mink with the autosomal recessive (aa) Aleutian (blue) coat color in 1940.34 It was initially diagnosed in the ferret in the 1960s and called hypergammaglobulinemia, based on the major clinical feature associated with the disease. There are variable strains of the Aleutian disease virus (ADV) that display varying virulence and immunogenicity. Ferret strains are considered mutants of the mink ADV strains. Unlike mink, ferrets display a milder disease and may even be infected for years without exhibiting clinical signs.34,35 Transmission of ADV occurs ferret to ferret or mink to ferret through aerosolization of viral particles; direct contact with the urine, saliva, blood, or feces of infected animals; or via contaminated fomites.34,35 Vertical transmission occurs in the mink but has not been positively identified in the ferret. All seropositive ferrets, regardless of clinical disease status, should be considered sources of infection.

Aleutian disease is an immune-mediated disease, characterized most commonly by the presence of a hypergammaglobulinemia. The severity of disease is dependent upon the origin of the ADV (ferret vs. mink). When mink are infected, ADV causes hypergammaglobulinemia, glomerulonephritis, arteritis, plasmacytosis, progressive wasting, and death within 5 months.25 When ferrets are infected, the mink strain of ADV causes mild lesions and moderate increases in gammaglobulins, whereas the ferret strain of ADV causes a marked, persistent hypergammaglobulinemia and periportal lymphocytic infiltrates.34 Glomerulonephritis and vasculitis are not as severe in the ferret as in mink, which may be due to lower levels of circulating viral antigen that results in a reduction in immune complex deposition.34,36 Plasmacytic-lymphocytic infiltrates have been found in multiple organs, including the central nervous system.34,36

In some cases, death may occur without the development of clinical signs. ADV can cause chronic, progressive weight loss, cachexia, malaise, and melena.25,34 Posterior paresis is the most consistent clinical sign.34,38 Adults may clear the virus or
become persistently infected without ever showing signs of disease.\textsuperscript{25,34,35} Differentials for chronic weight loss should include neoplasia, cardiac disease, estrogen-induced anemia, and gastrointestinal disease (e.g., malabsorption, maldigestion, bacterial enteritis, cosinophilic gastroenteritis, proliferative bowel disease). The neuroparalytic form of CDV or rabies should also be considered in the presence of neurologic signs.

A presumptive diagnosis of ADV infection can be established based on a history of chronic weight loss and the presence of a hypergammaglobulinemia on serum protein electrophoresis, with gammaglobulins making up greater than 20\% of the total protein.\textsuperscript{35} Two tests are available to confirm a diagnosis of ADV: counterelectrophoresis and immunofluorescent antibody test.\textsuperscript{35,34} Counterimmunoelectrophoresis is a popular screening test for the same disease in mink. It is a highly specific test, but unfortunately, it does not distinguish between strains of ADV and does not detect antibody to specific antigen of virus-infected cells.\textsuperscript{35} Immunofluorescent antibody testing may be more sensitive.\textsuperscript{23} PCR has also been utilized for the diagnosis of ADV.\textsuperscript{34,36}

Because there is no treatment for ADV infection, prevention of the disease in ferret households is recommended. This can be accomplished through testing of ferrets for the disease before introducing them into the household. Additionally, vaccination is contraindicated due to the immune-mediated effects of the disease and the inability of antibodies to neutralize the virus.\textsuperscript{34} Ferrets that are identified as persistently infected should either be isolated or culled. Ferrets also should not be exposed to mink.

\textbf{Rabies}
Rabies is a disease of mammals caused by Rhabdovirus. There have been fewer than 20 cases of rabies reported in ferrets since 1954.\textsuperscript{34} One of these cases occurred from the administration of a modified-live vaccine product that induced disease. There have been no reported cases of human rabies infection from exposure to an infected ferret. Additionally, there is a paucity of information of ferret vaccine history, clinical signs, or exposure to wildlife from the few reported cases of ferret rabies.

Experimental infection with rabies virus has induced ascending paralysis, ataxia, cachexia, fever, hyperactivity, bladder atony, tremors, and paresthesia.\textsuperscript{9} Susceptibility to infection and development of clinical signs seems to be based on the inoculum dose. Although there was a lack of shedding of the virus in the saliva, isolation of the virus in the salivary glands was accomplished in a single ferret.\textsuperscript{9,34}

Any unvaccinated ferret suspected of being infected with rabies virus should be euthanized and submitted to the state public health laboratory for confirmation. The diagnosis is based on direct immunofluorescent antibody testing of brain tissue. Vaccinated ferrets that inflict a bite to a human are required to undergo the same quarantine protocol as vaccinated dogs and cats. Because there is no treatment for this disease, prevention through vaccination is highly recommended. There are varying civic, county, and state laws regarding ferret ownership, and ferret owners should always inquire about the current ownership regulations, including vaccination requirements of their town, county, and state.

\section*{Fungal Disease}
Fungal infection should be considered a top differential diagnosis for any persistent infections that are nonresponsive to antibiotics, particularly if other systemic signs, such as pyrexia, respiratory, or neurologic signs, are present. Histologic and cytoclogic examination and culture of discharge, tracheal washes, and cerebrospinal fluid samples can allow direct visualization and identification of the organism.

Pulmonary mycoses have been described in some ferrets exhibiting signs of coughing, wasting, lethargy, anorexia, lymph node enlargement, and oculonasal discharge. \textit{Blastomyces dermatitidis} infection has been diagnosed in ferrets in the southeastern United States, Mississippi River valley, and Ohio River valley.\textsuperscript{24} In addition to pulmonary disease, \textit{Blastomyces} has also been involved in the development of multifocal granulomatous meningoencephalitis.\textsuperscript{22} \textit{Coccidioidomyces immitis} has been diagnosed as an etiologic agent of pulmonary disease in the southwest United States.\textsuperscript{24} Pulmonary signs tend to develop 1 to 3 weeks after infection with this organism.

Diagnosis of these fungal infections is based on clinical signs, radiographic changes, and identification of the organism. Radiographs may reveal multiple fungal granulomas throughout all lung lobes. A tracheal wash may be used to collect samples for cytoclogic examination. Culture of the wash may also be beneficial, particularly if the organism cannot be identified by microscopic examination of the wash. Although amphotericin B and ketoconazole have been used for the treatment of ferrets infected with these organisms, the prognosis is usually poor.\textsuperscript{22}

The incidence of dermatophytosis seems to vary according to geographic location.\textsuperscript{40} Both \textit{Microsporum canis} and \textit{Trichophyton mentagrophytes} have been diagnosed in ferrets. These organisms are transmitted by direct contact with infected animals or contaminated fomites, and infection has been associated with overcrowding. Dermatophytosis is much more common in younger ferrets and is usually self-limiting. The skin and hair lesions are similar to those seen in other mammals, with small patches of alopecia and papules that spread peripherally, leading to crusting and erythematous pruritus. There may also be excoriation and secondary pyoderma due to associated pruritus.

Diagnosis is based on mycotic culture of a skin scrape or hair sample, or by biopsy of the lesion. Microscopic examination of the organisms grown in culture will reveal characteristic fungal arthrospores that allow for identification of the pathogen. \textit{M. canis} will fluoresce under a Woods lamp in fewer than 50\% of the cases.\textsuperscript{40} Successful treatment of these cases requires clipping the hair surrounding the lesions and applying keratolytic shampoo, povidone-iodine, or chlorhexidine scrubs, and antifungal medications. Griseofulvin can be used at 25 mg/kg orally once a day for 21 to 30 days.\textsuperscript{30,40} Adverse effects of griseofulvin treatment have not been reported in ferrets; however, it should not be used in breeding animals, and the CBC should be monitored every 2 weeks. As mentioned, this disease process is usually self-limiting and medical intervention is not always necessary. The environment will require disinfection to prevent reinfection of the organism.
Because dermatophytosis is a zoonotic disease, clients should be educated on the potential risk of infection.

**Parasitic Disease**

**ECTOPARASITES**

Ectoparasites can be common in pet ferrets, especially animals that are housed outdoors. Ferrets may become infested with *Ctenocephalides* spp. the same species of fleas that affects dogs and cats. Infestation may be acquired directly from another animal infested with fleas or exposure to an infested environment. Affected ferrets may experience mild to intense pruritus and develop erythemic papules or alopecia over the dorsal cervical and interscapular areas. Evidence of fleas may be noted as reddish-black “dirt” within the fur over the back, or fleas may be seen in the coat or around the face. Treatment involves eliminating the fleas on the ferret, in the environment, and on any other animals within the household. Compounds that are approved for use in cats may be used to treat flea-infested ferrets. Caution should be exercised when topical flea control is applied because toxic overdose to these small animals may occur. Organophosphates, dips, and Dichlorvos-impregnated collars should not be used because of the potential for toxicity. Frontline (Merial Limited, Duluth, GA) can be used topically as a flea preventative and treatment. To apply Frontline, a cloth should be sprayed and used to wipe down the ferret for treatment. Lufenuron (Program; Ciba Animal Health, Greensboro, NC), given at the cat dose, can also be used for treatment and is applied to the mid-dorsal region at the level of the shoulders.

The ferret ear mite, *Otodectes cynotis*, is also commonly diagnosed in pet ferrets. This ear mite is directly transmitted between animals. Ferrets with ear mites may be subclinical, or they may shake their head or scratch at their ears. Although mite infestations are often associated with heavy brown, waxy otic exudate, this exudate is also found in mite-free ferrets. Microscopic examination of otic exudate can be used for diagnosis, allowing for direct visualization of the mites. When a diagnosis is made, all susceptible animals within the household should be treated. Ivermectin can be administered subcutaneously at 0.2 to 0.4 mg/kg every 14 days until resolution, or it can be used topically in each ear at a dosage of 0.5 mg/kg divided between the two ears. To facilitate topical treatment, the ears should be cleaned before treatment. Tresaderm (Merck Agvet Division, Rahway, NJ)—a topical combination of thiabendazole, dexamethasone, and neomycin—can also be used, with a recommended treatment of 7 days application, 7 days off medication, and then 7 more days of treatment.

Ferrets are also susceptible to *Sarcoptes scabiei*, acquiring the mite directly from infested animals or from a contaminated environment. There are two conditions described in ferrets, both of which are characterized by intense pruritus of the affected areas. The first is a generalized form that consists of focal to generalized alopecia that may involve the face, the pinnae, and/or the ventrum. The second clinical presentation is localized, usually involving only the paws, which often appear inflamed, swollen, and crusted. Severe infestations can result in deformity of the nails or loss of the nails or toes. Diagnosis can be made by skin scrape, although false negatives are possible. Treatment should consist of ivermectin administered at a dosage of 0.2 to 0.4 mg/kg subcutaneously every 14 days until resolution. Alternatively, weekly lime sulfur dips at a dilution of 1:40 may be used for up to 6 weeks. Unfortunately, the use of lime sulfur dips will result in discoloration of the fur and a very strong odor. Prednisone and antibiotics can be added systemically or topically to alleviate pruritus and secondary dermal bacterial infections. All animals in the household should be treated and the environment should be decontaminated to ensure complete resolution.

Infestation with ticks and myiasis has been seen in ferrets housed outdoors. *Cuterebra* has been diagnosed in the subcutis of a ferret’s neck. It can be recognized by a swollen area containing an open pore. *Wohlfahrtia vigil*, the flesh fly, has been reported in commercially ranched mink and ferrets. Mink kits of 4 to 5 weeks of age may be affected during the summer months. Eggs are laid on the face, neck, or flanks, where larvae bore into the subcutis and cause irritation. Infestation with *Hypoderma bovis* in the cervical area has also been documented in ferrets. Myiasis treatment involves surgical removal of the larva, debridement of the surrounding tissue, and topical application of antibiotics to the affected tissue.

**ENDOPARASITES**

Endoparasites are uncommon in pet ferrets; however, any ferret presenting with diarrhea should have a fecal exam performed. Juveniles are susceptible to coccidiosis or giardiasis infestation. *Isospora* and *Eimeria* species have been identified in ferrets. Ferrets diagnosed with coccidiosis may be subclinical or present with diarrhea, lethargy, dehydration, or rectal prolapse. Coccidial infections are usually self-limiting, but ferrets may develop a chronic carrier state. *Cryptosporidium* sp. has more recently been described in ferrets but is not associated with clinical disease. It may cross species barriers, and ferrets acquire it by ingesting infective oocysts. It can be diagnosed by acid fast staining of the feces, with oocysts staining a bright pink, or by flotation in Sheather’s sugar. Infection with the *Cryptosporidium* organism appears to be self-limiting and does not require treatment. Treatment of endoparasites involves the use of common anthelmintic drugs and should follow the published ferret dosages of these therapeutic agents.

**HEARTWORM DISEASE**

Ferrets are susceptible to natural infection by the filarial nematode *Dirofilaria immitis*, the etiologic agent of heartworm disease. The parasitic larvae develop in, and are transmitted by, the mosquito, and infection is of particular concern for ferrets in endemic regions. Clinical signs of infection include dyspnea, cough, pale mucous membrane, lethargy, or anorexia. Muffled heart sounds or a grade II or III murmur may be heard on auscultation of heartworm-positive animals. Radiographs may reveal an enlarged heart, pulmonary congestion, pleural effusion, and possibly ascites. Echocardiography can be a definitive diagnostic test of heartworm disease, with the worms directly visualized as hyperechoic densities within the right
atrium and ventricle. Circulating microfilaria is uncommon in the ferret; however, a blood smear is necessary for diagnostic evaluation. Two ELISA diagnostic tests have been used successfully to identify circulating heartworm antigen in ferrets: the Snap Heartworm Antigen Test Kit (IDEXX Laboratories, Inc., Westbrook, ME) and Dirocheck Occult Heartworm kit (Symbiotics, San Diego, CA).

On necropsy, infected ferrets have been found to carry 1 to 10 worms, located in the right heart, the pulmonary artery, and the cranial and caudal venae cavae.

Treatment of ferrets with heartworm disease can be difficult because of the risk of fatal pulmonary thrombembolism. To reduce this risk, ferrets should be pretreated with heparin at a dosage of 100 U/lb of body weight once a day for 3 days before adulticide therapy and continued for an additional 2 to 3 weeks. When heparin treatment is complete, aspirin should be initiated at 10 mg/kg once a day for 3 months. An alternative for heparin is prednisolone given at 2.2 mg/kg once a day for 3 months. Adulticide therapy involves the administration of 0.22 ml/kg of thiacetarsamide (Capreolate) intravenously every 12 hours for 4 injections. Heartworm prevention can be initiated 1 month after adulticide therapy is completed. A follow-up ELISA should be checked 3 months after treatment and at monthly intervals thereafter until negative results are achieved. During adulticide therapy, treatment for cardiac failure should also be considered depending on case presentation and patient response.

Ferrets living in heartworm endemic regions should be placed on yearly preventative medication. Oral ivermectin formulated for dogs (Heartguard-30; Merck Agvet Division, Rahway, NJ) can be administered once a month as a preventative. One quarter of the smallest tablet should be given. The remainder of the pill should be discarded, as the drug deteriorates after the pill is broken. Alternatively, an oral suspension of ivermectin can be administered at the recommended dose of 6 μg/kg and up to 1 mg/kg orally once a month. This can be accomplished by mixing 0.3 ml of 1% injectable ivermectin in 28 ml of propylene glycol, creating a concentration of 0.1 mg/ml. A dosage of 0.2 ml/kg can be administered once a month, which will provide a prophylactic dosage of 0.02 mg/kg. The suspension should be protected from light and given a 2-year expiration date.

Nutritional Disease

UROLITHIASIS

The most common nutritional disease of ferrets is urolithiasis. This disease is often diagnosed in ferrets that are fed diets consisting of poor quality dog or cat food. These poor quality diets contain high levels of plant proteins that alkalinize the urine and predispose the animal to crystalluria and stone formation. The normal urine pH of ferrets ranges from 6.5 to 7.5, but ferrets that are fed high-quality, meat-based diets tend to have a pH around 6.0. Magnesium ammonium phosphate (struvite) makes up the most commonly reported uroliths in ferrets (see Figure 13-2). They can form anywhere in the urinary tract but are commonly found in the kidney, bladder, and urethra. Nondietary causes of urolithiasis include urinary tract infection with urease-producing bacteria, also resulting in urinary alkalinization, or renal injury leading to increased mineral excretion.

Ferrets with urolithiasis exhibit signs consistent with urinary tract obstruction in other mammals. These signs may include stranguria, dribbling urine, frequent urination, hematuria, vocalization with urination, wet fur or skin irritation of the perineum or preputial areas, or frequent licking of the perineum or preputial areas. Some ferrets may show no initial signs of obstruction but show lethargy or inappetence. Palpation of the abdomen will reveal a distended bladder and may elicit vocalization from pain. Males present more commonly for urethral obstruction, as stones will often become lodged at the base of the os penis. Obstructed ferrets are at major risk for severe metabolic disturbances, bladder rupture, structural kidney damage, and even death. Steps should be taken immediately to alleviate the build-up of urine, in obstructed ferrets, through catheterization or cystostomy.

Once the patient has been stabilized, a full diagnostic work-up can be done to identify the cause of urinary obstruction. Common differential diagnoses include urolithiasis, prostatomegaly, prostatic cysts, gross pyuria, and possibly neoplasia. A CBC and serum chemistry panel should be performed to identify the presence of any infectious processes or metabolic abnormalities. Reliable urinalysis results are obtained from a sample acquired via cystecstoscopy and should include a gross exam for crystal identification and culture and sensitivity for bacterial identification. Radiographs are helpful in the diagnosis and location of uroliths and in ruling out other diseases, such as prostatomegaly. Ultrasonography can provide additional information when the patient presents with radiolucent stones, prostatomegaly, or prostatic cysts.

As mentioned previously, urinary obstructed patients should be immediately stabilized by urinary catheterization and correction of any metabolic disturbances. If catheterization cannot be accomplished, cystostomy can be used for immediate reduction of the bladder. After the bladder has been reduced via cystostomy, retrograde flushing of the urolith into the bladder can be attempted by placing a catheter partially into the urethra and pinching closed the prepucce while flushing the urethra with sterile saline. If catheterization is still not possible, a temporary tube cystotomy may be necessary. Once the patient has been stabilized, a cystotomy can be performed for stone retrieval, either directly from the bladder or by anterograde flushing of the urethra to dislodge the calculi. Stones should then be submitted for analysis to determine the proper course of treatment and prevent further stone formation. Should removal of the stone be unsuccessful, a perineal urethrostomy is indicated. This procedure should be performed caudal to the base of the os penis in males. A perineal urethrostomy is indicated only in the treatment of urethral obstruction caused by urolithiasis, as it will be unsuccessful in cases of prostatic disease. Renal uroliths may require unilateral nephrectomy.

Long-term treatment of urolithiasis requires the use of antimicrobial therapy for 10 to 14 days and a diet change to one that is higher in animal-based proteins. A commercially prepared
Neoplasia

Ferrets were once thought to have a very low incidence of neoplasia. Although the true incidence is not known, the number of neoplastic cases has risen over the years. This may be due, in part, to the recent increased popularity of the ferret as a pet and laboratory animal. Several etiologies have been proposed for the development of neoplastic diseases in the ferret, including genetic predisposition, early neutering at 5 to 6 weeks of age, the lack of a natural photoperiod, exposure to carcinogenic substances, as well as an infectious agent. A variety of neoplastic diseases have been described in ferrets, but only a few are diagnosed with any regularity (e.g., adrenocortical cell tumors, insulina, lymphoma, cutaneous neoplasms). Tumors have been found in most systems of the ferret body, including the gastrointestinal, reproductive, urinary, and musculoskeletal systems.

ADRENAL GLAND DISEASE

Adrenal gland disease is an endocrinopathic disease commonly found in ferrets in the United States, affecting middle-aged to older spayed or neutered ferrets. There is no sex predilection; males and females are equally affected. It is commonly diagnosed as adenoma, adenocarcinoma, or adrenal hyperplasia. Adrenal gland disease in ferrets differs from that of dogs in that the disease is characterized by the hypersecretion of sex steroids rather than cortisol. In ferrets, one or more sex steroids such as androstenedione, dehydroepiandrosterone sulfate (DHEA), estradiol, or 17-hydroxyprogesterone (17-OHP) will be elevated, whereas cortisol levels are usually significantly lower. A diagnosis of adrenal gland disease is based on the history and clinical signs and confirmed by demonstration of elevated sex hormones or ultrasound evaluation. Concurrent disease is often present, and a full work-up is indicated to determine the scope of illness. A CBC is usually normal in a ferret with adrenal disease unless bone marrow toxicity is present, in which case there will be evidence of anemia and pancytopenia. The serum biochemistry panel is somewhat more helpful in identifying the presence of concurrent disease, as an elevated alanine aminotransferase (ALT) may be the only change associated with adrenal gland disease. Radiographs are also indicated in ruling out additional disease, such as prostatomegaly or splenomegaly. Ultrasonography is useful for diagnostic support of adrenal gland disease, allowing the clinician to identify abnormalities in shape, size, or thickness of the adrenal glands. It is important to note, however, that normal adrenal glands determined by ultrasound evaluation does not exclude disease.

The measurement of sex hormones may be used to confirm a diagnosis of adrenal gland disease. Plasma concentrations of 17-OHP, DHEA, and androstenedione are significantly higher in adrenal gland disease. The Clinical Endocrinology Service of Comparative Medicine at the University of Tennessee College of Veterinary Medicine (Knoxville, TN) currently offers measurement of estradiol, androstenedione, and 17-OHP for the diagnosis of adrenal gland disease (Box 13-4). A volume of at least 0.5 ml of serum is required for testing and should be shipped frozen, overnight to the lab. Results are usually reported in about 1 week.

Options for the treatment of adrenal gland disease include medical or surgical therapy. Surgical treatment also provides the opportunity to explore the abdomen and surgically correct any abnormalities noted. The left adrenal gland is more easily removed, as the right adrenal gland is located adjacent to the caudal vena cava. When a single gland is affected, unilateral adrenalectomy should be performed and the contralateral gland debulked if necessary. If disease is present in both adrenal glands, complete removal of adrenal tissue may be difficult. Because of the close proximity of the...
right adrenal gland to the caudal vena cava, a partial adrenalectomy of the right gland and a complete adrenalectomy of the left gland are recommended. This technique also reduces the need for postsurgical supplemental glucocorticoid therapy. The reported recurrence rate with development of disease of the contralateral gland following unilateral adrenalectomy is 17%, whereas recurrence following subtotal bilateral adrenalectomy is 15% 7 to 22 months after surgery.49,58

Alternatively, medical therapy is an option in the treatment of adrenal gland disease. Mitotane was previously recommended for this treatment; however, unlike canine Cushing’s disease, ferret adrenal gland disease is nonresponsive. Leuprolide acetate, a long-acting gonadotropin-releasing hormone, is now recommended for the treatment of this disease in ferrets. It acts by suppressing the gonadotropins that are released by the pituitary gland, and it reduces elevated sex hormone levels and eliminates clinical signs.54 A 3.75-mg, 30-day preparation of leuprolide acetate (Lupron Depot, TAP Pharmaceuticals, Inc., Deerfield, IL) can be administered at a dose of 100 μg intramuscularly every 30 days for ferrets weighing less than 1 kg, and 200 μg intramuscularly every 30 days for ferrets over 1 kg.59 Injections must continue to be administered at regular intervals to prevent redevelopment of clinical signs. The use of this drug may be cost-prohibitive for some clients, and response to the drug has been variable. The differences in response may be a function of the type of disease process present, hyperplasia versus adenoma or adenocarcinoma, but this has not been evaluated. Additionally, the long-term safety and efficacy of Lupron administration has yet to be determined.

Males with adrenal gland disease that have partial or complete urinary obstruction from prostatomegaly require emergency intervention to empty the distended bladder (Figure 13-3). Manual expression, urethral catheterization, or cystocentesis should be cautiously attempted. As mentioned previously, prostatomegaly caused by adrenal gland disease is hormone responsive, and the prompt surgical removal of the affected gland will resolve urethral obstruction by the enlarged prostate in 24 to 48 hours. Leuprolide acetate has been successful in eliminating obstruction by reducing the sex hormone levels triggering enlargement of the prostate. Bicalutamide, an androgen blocker, has also been suggested at a dosage of 5 mg/kg orally once a day.60

The prognosis for ferrets with adrenal gland disease–associated alopecia is good, even without treatment. However, when adrenal gland disease leads to more severe complications, such as bone marrow toxicity, urethral obstruction, or metastasis, the prognosis becomes poor to grave if treatment is not initiated.

INSULINOMA

Insulinoma is a very common neoplastic disease of middle-aged to older ferrets, with males being slightly more susceptible than females.50-54,61-64 It is a beta cell tumor of the pancreas that is characterized by hypersecretion of insulin, thus lowering blood glucose by driving glucose into the cells and decreasing hepatic gluconeogenesis and glycogenolysis. It causes an increase in the basal insulin level, and it is highly responsive to stimulation yet unresponsive to inhibitory mediators.60

Ferrets affected by insulinoma show signs of hypoglycemia, which may be variable depending on the degree of hypoglycemia and the rate of blood glucose decline. Early signs may be slow and insidious in their development and are not easily recognized by the owner. Such signs include a reduction in activity, weight loss, and difficult arousal from slumber. As the disease progresses and hypoglycemia worsens, more significant clinical signs develop, such as hypothermia, pyralism, mental dullness, tremors, acute collapse, or a classic glassy-eyed appearance. Because pyralism is associated with nausea, other diseases such as gastric ulcers or foreign body should be ruled out. Ferrets severely affected by low blood glucose may even have seizures or be comatose. Signs of acute collapse or unresponsiveness can be reversed temporarily with the application of a dextrose solution on the oral mucosa. Insulinoma may also be inadvertently identified in asymptomatic ferrets during the diagnostic work-up of disease processes.

A presumptive diagnosis of insulinoma is made based on the history, clinical signs, and the demonstration of hypoglycemia with a blood glucose test. Although insulinoma is much more common, other differentials for hypoglycemia should be considered, such as liver disease, sepsis, sample mishandling, or neoplasia.62,63 The diagnosis of insulinoma is confirmed by biopsy and histopathology of affected pancreatic tissue.

The normal range for resting blood glucose in the ferret should be 94 to 207 mg/dl, while the fasting glucose should be 90 to 125 mg/dl.50 Blood glucose measurements below

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**Hormone** | **Range**
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Estradiol (pmol/L) | 30-180
17-α-hydroxyprogesterone (nmol/L) | 0-0.8
Androstenedione (nmol/L) | 0-15

*Reference ranges are from the Clinical Endocrinology Service of the University of Tennessee College of Veterinary Medicine.

**Figure 13-3** This 5-year-old male ferret with adrenal gland disease has a urethral obstruction secondary to prostatomegaly, resulting in a grossly distended bladder.
70 mg/dl are strongly suggestive of hypoglycemia. A 4- to 6-hour fast is helpful to determine a diagnosis; however, this is not recommended or necessary in animals showing clinical signs consistent with the disease. A human glucometer developed for diabetic patients facilitates measurement of blood glucose in practice, although these devices have not been validated for the ferret. Increased insulin levels and insulin : glucose ratio are also supportive of a diagnosis of insulinoma, but it is possible that ferrets with this disease may have normal insulin levels. Additional parameters on a serum biochemical assay are typically within normal limits, with the exception of an elevated ALT. Radiography and ultrasonography are not helpful in the diagnosis of insulinaemia in most cases, but they may assist in the identification of concurrent disease or metastasis.

Treatment of insulinoma may be accomplished medically or surgically. Medical treatment involves dietary management and the administration of prednisone, diazoxide, or octreotide, alone or in combination. Prednisone acts by blocking peripheral uptake of glucose by cells and increasing hepatic gluconeogenesis. Initially it can be dosed at 0.25 mg/kg orally every 12 hours, but it can be increased up to 2 mg/kg every 12 hours as needed to control hypoglycemia. Prednisone has the unfortunate characteristic of a bitter taste, and ferrets tend to object to its administration. To improve palatability and acceptance, preparations containing alcohol should be avoided. Pediatric formulations of prednisone and prednisolone are available; the formulations Orapred (Lyne Laboratories, Inc., Brockton, MA) and Pediapred (Medeva Pharmaceuticals, Rochester, NY) work quite well. Smaller doses of prednisone can be used when diazoxide, a benzothiadiazine derivative, is added to the treatment plan. Diazoxide functions to antagonize the effects of insulin. It too has a broad dose range, which can be started at 10 mg/kg orally and divided twice a day, and increased to 60 mg/kg divided twice daily as needed. Disadvantages associated with diazoxide include expense and gastrointestinal complications (e.g., vomiting and anorexia). A 50-mg/ml suspension of diazoxide is available (Proglycem; Baker Norton Pharmaceuticals, Miami, FL), as well as 100-mg pills (Proglycem; Schering Canada, Inc., Pointe-Claire, Quebec, Canada), which can be compounded to a suspension at a lesser expense to the owner. The use of prednisone and diazoxide in combination should improve the blood glucose levels of the ferret in 24 to 48 hours. As neither drug slows or stops tumor growth, the dosages will need to be increased periodically as the disease progresses. Octreotide is a somatostatin analog that inhibits insulin secretion by the pancreatic tumor. Because Octreotide requires subcutaneous injection every 12 hours; it is rarely used to treat ferrets diagnosed with insulinoma. Dietary management involves the feeding of meals high in protein and fat, 3 to 4 times a day. Simple sugars should not be offered. The blood glucose is measured daily until clinical signs are eliminated and weekly until the fasting blood glucose is within the normal range; drug dosages should be adjusted as needed. Thereafter, the affected ferret’s blood glucose level should be rechecked every 3 months to ensure successful treatment.

Surgical treatment by nodulectomy or partial pancreatectomy is the preferred method of treatment. Unlike insulinoma in dogs, which is characterized by the presence of a single pancreatic mass, ferret insulinoma involves multiple nodules of the pancreas that may affect one or both lobes. Because many of the nodules may be microscopic foci, nodulectomy combined with partial pancreatectomy can increase considerably the disease-free interval and survival times. Metastasis is not uncommon in ferrets; local lymph nodes, liver, and spleen should be examined at the time of surgery for evidence of metastasis. Complications such as pancreatitis or iatrogenic diabetes are rare with surgical intervention. It is important to note, that although the disease-free interval is increased with surgical therapy, recurrence is typically seen 7 to 10 months after surgery. Medical therapy is usually chosen upon recurrence of the disease. The blood glucose should be measured immediately after surgery, at 1 month, and every 3 months thereafter to promptly initiate therapy with recurrence.

The average survival time with treatment following the diagnosis of insulinoma is 16 months. Prognosis seems to be associated with the duration of clinical signs before diagnosis and initiation of treatment. Ferrets with a longer duration of hypoglycemia tend to have a shorter disease-free interval and decreased survival times. Therefore, early recognition, diagnosis, and prompt treatment can make a difference in prognosis for ferrets with this disease.

**LYMPHOMA**

Lymphoma is the most common neoplastic disease affecting young ferrets. It is typically diagnosed in ferrets aged 6 months to 1 year and 3 to 5 years. Numerous tissues are associated with this disease, including peripheral and visceral lymph nodes, spleen, liver, intestines, bone marrow, lung, and kidney. In young ferrets, the disease has an acute onset and is characterized by a rapidly progressive, multicentric distribution of disease, commonly involving hematopoietic and lymphatic tissues, lung and kidney. Adult lymphoma is more chronic and survival times tend to be greater. The cluster outbreaks that have occurred in juveniles have led to the suspicion that a viral agent, specifically a retrovirus, may play a role in the etiology of juvenile lymphoma, and is currently under investigation. FeLV and ADV have been suggested as possible etiologic agents, but testing has not supported this theory.

Nonspecific clinical signs are often associated with lymphoma in the ferret (e.g., anorexia, weight loss, lethargy). Mediastinal lymphoma, a common finding in young ferrets, may result in dyspnea, coughing, or regurgitation (Figure 13-4). Adults may exhibit intermittent nonspecific signs that improve with corticosteroid use. Emesis, diarrhea, or tenesmus may be observed in ferrets with gastrointestinal or abdominal lymphoma, and the patient may have multiple palpable masses in the abdomen or peripheral lymphadenopathy. The peripheral lymph nodes are often surrounded by fat and should not be confused with enlarged lymph nodes that are a consequence of lymphosarcoma. Splenomegaly is a common finding and may be a result of neoplastic infiltrate or extramedullary hematopoiesis.

A CBC and serum biochemistry panel should be performed on any ferret suspected of having neoplastic disease. A CBC
may reveal mild anemia and a normal or elevated white blood cell count. In young ferrets, a lymphocytosis is common, whereas in older ferrets, a lymphopenia is much more common. The lymphocytosis generally exceeds 3500 cells/mm³ or comprises greater than 60% of the total white blood cell count. Less than 25% of lymphoma cases may be characterized as lymphoblastic leukemia. Radiographs should be obtained from the dyspneic patient and are helpful in identifying the presence of a mediastinal mass, pleural effusion, or organomegaly (Figure 13-5). Fine needle aspiration and biopsy are quite useful for the definitive diagnosis of lymphoma. A fine needle aspirate should be performed on any masses or pleural effusion. The thoracic aspirate of pleural effusion allows for the differentiation between lymphoma, cardiac disease, pyothorax, or chylothorax. A bone marrow aspirate should be performed on any ferrets with evidence of leukemia, anemia, or atypical lymphocytes on the CBC. A peripheral lymph node biopsy or nodectomy with subsequent histopathologic evaluation of the tissue sample, particularly of the popliteal lymph node, is ideal for confirming a diagnosis of lymphoma in the ferret. This can be beneficial in determining the diagnosis even if performed on a lymph node of normal size. Histopathologic examination of an enlarged peripheral lymph node may reveal lymphoid hyperplasia, which is often caused by viral infection or chronic antigenic stimulation. Histopathologic classification of ferret lymphoma cases are high grade, diffuse, small noncleaved, or immunoblastic in young. Older ferret lymphoma cases have been classified as mixed cell immunoblastic (most commonly) or mature lymphocytic.

Once a definitive diagnosis of lymphoma has been made, a treatment protocol must be pursued. The ideal therapy is surgical removal of any solid masses combined with systemic chemotherapy. Young ferrets with multicentric distribution of disease typically respond poorly to chemotherapy and have short survival times. Ferrets with concurrent disease have a greater risk of complications associated with chemotherapy. Additionally, those that have been previously treated with corticosteroids have a poor response to chemotherapy. The prognosis for ferrets with no overt clinical signs, but which were diagnosed based on chronic lymphocytosis and a positive lymph node biopsy, is variable. Older ferrets probably respond better because the neoplasia has a slower growth rate.
Treatment should never be considered curative for a ferret patient diagnosed with lymphoma. Remission can be achieved with marked improvement or return to a clinically normal state. Remission may be defined as resolution of organomegaly and a normal CBC. Biopsy, however, may show persistence of disease. Remission may last for 3 months to 5 years, during which time a patient’s CBC should be monitored every 1 to 3 months.

Protocols for chemotherapy for lymphoma are listed in Table 13-6. Before the initiation of chemotherapy a full patient evaluation should be made, consisting of a CBC, serum biochemistry panel, radiographs, and bone marrow aspirate. This allows for the complete assessment of the patient for risks associated with, and prognosis for, response to therapy. Patients with greater than 50% of the bone marrow composed of malignant cells are at a high risk for fatal complications from chemotherapy. The client should be educated on the need for complete compliance, good nutritional support, and close monitoring of the patient. Side effects are dependent on the drugs that are used, but they are the same as those described in other species. Lethargy, posterior paresis, anorexia, vomiting, mild hair loss, dyspnea, and collapse are the most common side effects seen in ferrets. They may occur as soon as 1 to 2 days posttreatment or as late as 2 weeks posttreatment. Veterinarians should always follow standard safety protocols when using antineoplastic drugs. Intravenous drug administration should be performed under anesthesia, using an indwelling catheter. To ensure patency, the catheter should always be flushed before drug administration, and extravasation should be managed according to procedures appropriate for the drug. With doxorubicin, the catheter should not be flushed with heparinized saline, as the heparin will cause the doxorubicin to precipitate out. The CBC should be evaluated no more than 24 hours before each treatment. Should the total white blood cell count drop below 1500/mm, the PCV below 30%, or the patient become debilitated, treatment should be discontinued or postponed until the physiologic parameters return to normal. The CBC should be rechecked 1 to 2 times a week until it has returned to normal limits. Additionally, nutritional support during chemotherapy is very important. The administration of Nutri-Cal, meat baby food, or Hill’s Prescription Diet Canine/Feline a/d may be used as a nutritional supplement.

Patients that are poor candidates for antineoplastic therapy can be treated with glucocorticoids. This therapy would not be myelosuppressive and can potentially destroy sensitive tumor cells. Glucocorticoid medication can be given at a dosage of 0.5 mg/kg orally every 12 hours and increased as needed to control clinical disease signs. Glucocorticoid therapy should not be used in asymptomatic ferrets, as there is the risk of resistance to treatment when signs develop and therapy is needed most. Herbal and homeopathic therapies have also been attempted with some success. A combination of vitamin C and Pau d’Arco has been used. Vitamin C acts as an antioxidant and stimulates the immune system. The chelated, buffered, or ester form can be given at 50 to 100 mg/kg orally twice a day. Pau d’Arco also acts to support the...
involves amputation of the tail cranial to the chordoma. The treatment of choice is surgical removal of the mass, which usually is performed to determine if metastasis has already occurred. The ferret, and surgical excision yields a good prognosis. Metastasis and local regrowth of this type of tumor are rare in older ferrets. 48 Areas where cutaneous neoplasms occur include the head, neck, shoulder, flank, legs, and feet. Biopsy and histopathology should be performed on all cutaneous masses to direct treatment and establish a prognosis. Some tumor types, such as basal cell and mast cell tumors, are benign and can be managed by complete surgical excision, with minimal risk of recurrence or metastasis. Others, such as adenocarcinoma, squamous cell carcinoma, or fibrosarcoma, have a greater tendency to metastasize and recur locally. Therefore, further evaluation, including CBC, serum biochemistry panel, and radiography, are warranted to fully assess the extent of disease.

Miscellaneous Tumors

CHORDOMAS

Chordomas are a common occurrence in ferrets and originate from residual notochord tissue. They are typically round, smooth, firm masses that develop on the tail. This tumor type has also occurred at the atlantooccipital joint and C2-C3 vertebrae. 47 Chordomas are slow-growing tumors, but metastasis can occur. As with other neoplasms, a full evaluation should be performed to determine if metastasis has already occurred. The treatment of choice is surgical removal of the mass, which usually involves amputation of the tail cranial to the chordoma.

Miscellaneous Diseases

UROGENITAL DISORDERS

Hyperestrogenism

Jills are seasonally polyestrous, induced ovulators; thus, if they are not bred or artificially stimulated to ovulate, they will remain in estrus. 22 Ferrets are quite susceptible to the effects of estrogen, and those that remain in estrus for periods longer than a month are at great risk for developing estrogen-induced bone marrow hypoplasia. 21 Physical signs of hyperestrogenism are similar to those of adrenal gland disease and natural estrus, with ferrets exhibiting a fleshy, swollen vulva, with or without discharge, and bilateral symmetric alopecia. Ferrets with hyperestrogenism are typically much younger than those with adrenal gland disease, with the average age being 1 to 2 years. In the United States, where ferrets are generally spayed before leaving a breeding facility, hyperestrogenism is rare. It is possible that a spayed female with remnant ovarian tissue may present for hyperestrogenism.

When the bone marrow is affected in hyperestrogenism cases, ferrets will become lethargic, inappetent, and weak, and will show signs of pale mucous membranes and subcutaneous or mucosal hemorrhage (e.g., petechiation, ecchymosis). At the onset of estrus, the ferret’s CBC will show a neutrophilia and thrombocytosis, but this will change to thrombocytopenia, leukopenia, and normocytic, normochromic, nonregenerative anemia when the bone marrow becomes affected. 21,22 Hyperestrogenism can be distinguished from adrenal gland disease based on age, history, clinical signs, and a response to the administration of hormones to stimulate ovulation.

Treatment of hyperestrogenism is ovariohysterectomy or surgery to search for and remove remnant ovarian tissue. Because of the significant anemia and thrombocytopenia associated with secondary bone marrow toxicity, surgery must be postponed in these ferrets until the ovaries have been stimulated to ovulate and the patient has been stabilized. A single injection of 100 IU human chorionic gonadotropin intramuscularly, repeated in 1 week if signs of estrus are still present after 3 to 4 days, will terminate estrus. 21,22,33 Alternatively, a single injection of gonadotropin-releasing hormone at 20 μg/kg intramuscularly or subcutaneously, also repeated in 1 to 2 weeks should signs of estrus persist, may be administered. 22 Treatment with antiestrogens such as tamoxifen citrate and clomiphene citrate should be avoided as they can have estrogenic effects in ferrets. 21,33 Treatment for bone marrow toxicity should include fluid therapy, iron and vitamin B supplementation, broad spectrum antibiotics, and enteral nutrition. Severely anemic and thrombocytopenic ferrets may require multiple whole blood transfusions. Once stabilized, the CBC should be rechecked with the patient in anestrus and again before surgery.

Ferrets not intended for breeding should be spayed to reduce or eliminate the risk of this disease. Prognosis for recovery of hyperestrogenism and bone marrow toxicity is dependent on the degree of anemia. If the PCV is greater than 20%, the patient has a good chance of recovery once the ovaries are stimulated to ovulate and surgery is performed. Ferrets with a
PCV below 15% have a grave prognosis, and aggressive medical intervention is required.

**Prostatic Disease**
Prostatic disease (e.g., prostatomegaly, prostatic cysts, and abscesses) is very common in male ferrets and is often secondary to adrenal disease. Significant enlargement of the prostate can lead to urethral obstruction. Prostatic disease may go undetected until signs of urinary obstruction or adrenal disease are noticed. In the normal ferret, the prostate is not palpable; however, when it is enlarged it can be palpated as a firm, soft tissue structure lying caudodorsally to the bladder. Treating the adrenal gland disease will often immediately correct the prostatic disease. Broad-spectrum antibiotics should be utilized in cases of prostatic abcessation. Grossly enlarged or infected prostates may require more aggressive intervention, such as surgical debulking or marsupialization for drainage of infected material.

**Renal Cysts**
There is, in general, a low incidence of renal disease in the ferret; however, renal cysts are commonly diagnosed. Renal cysts may be one or more in number and affect one or both kidneys. Unlike polycystic disease in other animals and humans, the disease in ferrets has not been found to involve other organs. Often cysts do not cause a problem for the ferret and will go undetected until found incidentally on palpation (one or more smooth masses on the kidneys) or ultrasound (one or more hypoechoic areas with smooth walls on the kidneys). Renal cysts have also been identified during abdominal exploratory surgery or necropsy. Renal cysts may cause a problem when a significant amount of the normal renal architecture is disrupted by the size of the cyst. When polycystic disease is identified, a CBC, serum biochemistry panel, and urinalysis should be performed to determine the effects of the cysts. Just as in the dog and the cat, the urea nitrogen and creatinine are used to evaluate renal function. Creatinine, however, declines very quickly in the blood of ferrets; therefore, any elevation should be considered significant. Ultrasonography can be used to evaluate renal architecture, and intravenous pyelography can be used to evaluate renal function. There is no treatment available for bilateral renal cystic disease. If one kidney is compromised by the presence of renal cysts, a unilateral nephrectomy can be performed if the opposite kidney has adequate function. Those ferrets that show no ill effect from polycystic disease do not require medical or surgical intervention.

**Eosinophilic Gastroenteritis**
Eosinophilic gastroenteritis is a disease process of ferrets that is more commonly reported in young ferrets. It is characterized by infiltration of the stomach wall, intestines, and mesenteric lymph nodes with eosinophils. As of yet, there is no confirmed etiology, but a food allergy has been proposed as a component of the disease process. Chronic diarrhea that is nonresponsive to antibiotic therapy is a common clinical sign associated with eosinophilic gastroenteritis, as are weight loss and anorexia. On abdominal palpation, intestinal loops may feel thickened and mesenteric lymph nodes enlarged. A CBC will often reveal eosinophilia. Diagnosis is confirmed with gastric or intestinal biopsy and histopathologic examination. Other GI pathogens should be investigated, including internal parasites or Helicobacter spp., which may contribute to the development of the disease. Treatment in ferrets is similar to that used in dogs, cats, and humans with eosinophilic gastroenteritis and is focused on reducing the inflammatory process. Prednisone at 1.25 to 2.5 mg/kg orally once a day is the treatment of choice for ferrets diagnosed with eosinophilic gastroenteritis. After the first week, the frequency of administration can be reduced to every 48 hours until clinical signs have completely resolved.

**Splenomegaly**
Splenomegaly is a very common finding in ferrets. Often it is an incidental finding in a clinically normal ferret, and it can occur as a primary or secondary disease process. Primary diseases of the spleen that can result in enlargement include lymphoma, primary splenic neoplasia, and ADV. Splenomegaly can be an incidental finding with any disease process, including insulinoma, adrenal gland disease, cardiac disease, and dental disease. Therefore, a full diagnostic work-up should be done to rule out concurrent disease, particularly in middle-aged to older ferrets.
CARDIAC DISORDERS

Cardiac disease is common in middle-aged to older ferrets. Often ferrets may have a history of nonspecific signs, such as inappetence, weight loss, lethargy, or rear limb paresis. Some ferrets are subclinical, and cardiac disease is an incidental finding on annual exam. Physical exam findings of cyanosis, increased capillary refill time, jugular distension or pulses, abnormal femoral pulses, or hypothermia are dependent on the severity of disease. 25,66 Results of auscultation vary, depending on the type of disease process present, but can include tachycardia, muffled heart sounds, left-sided holosystolic murmur, right-sided murmur, gallop rhythm, or pulmonary crackles. 25,66 Animals in cardiac failure commonly have ascites, hepatomegaly, or splenomegaly.

A diagnosis of heart disease is made based upon history and clinical signs, physical exam findings, radiographic evidence, electrocardiography (ECG), and echocardiography. Radiographically a globoid heart is commonly present and may be accompanied by pleural effusion, pulmonary venous congestion, or a diffuse interstitial pattern. Additional findings may include hepatomegaly, splenomegaly and ascites. An ECG is helpful in the identification of arrhythmias and conduction disturbances. Ideally the ECG should be performed without the aid of anesthesia. The ECG can be accomplished more efficiently by removing the metal teeth of the clasps, to which ferrets actively object, and utilizing techniques of distraction such as a Nutri-Cal treat. Ferret ECGs on lead II have small P waves that are similar to cats and large R waves similar to dogs. 25 Additionally, the normal ferret ECG will contain short QT intervals and elevated ST segments. Abnormal findings may include, but are not limited to, sinus tachycardia, atrial or ventricular premature complexes, sinus bradycardia, tall and wide QRS complexes, and depression of the ST segment. 25,66 The presence of a second- or third-degree atrioventricular block is indicative of significant heart disease. Echocardiography, also best performed without sedation, is useful in the assessment of chamber size, shape, function, pleural and pericardial effusion, and cardiac or mediastinal masses. Color flow Doppler imaging allows for evaluation of valvular insufficiency by providing information on the direction of blood flow and the presence of turbulence. 25 Additional tests, such as a CBC and serum biochemistry panel, can provide information of concurrent disease. Microfilarial testing and heartworm antigen testing can be used to diagnose heartworm disease. Thoracocentesis not only has diagnostic value but may also offer temporary respiratory relief to ferrets with pleural effusion. Dilated cardiomyopathy is the most commonly diagnosed cardiac disease in ferrets. 25 The cause of this disease is as yet unknown. Gross pathology reveals dilation of both atria and ventricles, and histopathology reveals multifocal myocardial degeneration, necrosis, and fibrosis. Treatment should be aimed at altering the heart rate, preload, afterload, and contractility. Hypertrophic cardiomyopathy is also diagnosed in ferrets. Ferrets with hypertrophic cardiomyopathy will have a thickened interventricular septum and a thickened left ventricular wall. 25 Histopathologically, these ferrets have fibrous connective tissue throughout the myocardium. The main objective of medical treatment is to improve diastolic function. The diagnosis of valvular disease in middle-aged ferrets is increasing. 25 In this disease process, valves become thickened and atra become dilated secondary to the developing valvular insufficiency. Myxomatous degeneration is a common histopathologic finding in valvular disease. 25 Another type of cardiac disease in ferrets is myocarditis, which is caused by toxoplasma-like organisms, ADV, sepsis, and heartworm disease. 25 There have been no reports of congenital cardiac disease or primary cardiac neoplasia in the ferret.

Treatment depends on the type of heart disease present and is based on treatment strategies in the dog and cat. Furosemide can be used safely in ferrets to alleviate fluid retention due to
Fluid Therapy

The ill or debilitated ferret often requires fluid therapy as part of its supportive care. The accepted daily maintenance fluid requirement for the ferret is 75 to 100 ml/kg/day. In addition to meeting the maintenance requirements, additional fluid doses should be calculated to replace ongoing losses and dehydration. Fluids can be easily administered subcutaneously in the ferret, with the fluid dose divided over 2 to 3 times a day. The loose skin over the neck, shoulder blades, and back are good places to administer subcutaneous fluids. Ferrets will often object to subcutaneous fluid administration, thus requiring adequate restraint. Severely debilitated animals may need intravenous or intraosseous fluid therapy administered continuously or 2 to 3 times a day. This can be accomplished with an infusion pump, a Buretrol device (Baxter Healthcare, Deerfield, IL), or a control flow regulator. The patient should be carefully monitored for fluid overload, which may result in dyspnea, harsh lung sounds, or a heart murmur. Fluid overload is an important concern in cardiac patients that can quickly overhydrate.

Lactated Ringer’s solution and Normosol are good options for fluid replacement in the ferret. Ferrets presenting for hypoglycemia may require the addition of 2.5% to 5% dextrose to the fluid therapy. Additional support can be provided to the debilitated patient through the addition of vitamin B or potassium to the fluids. The same protocols used in canine and feline medicine for the administration of these drugs should be applied to their use in the ferret.

Antimicrobials

Many of the same antimicrobial drugs of cats and dogs have been used safely in ferrets, and there are published drug dosages for ferrets. The same precautions and warnings for their use also apply to ferrets. An accurate body weight should be obtained from the ferret to properly dose the medications. The decision to use antimicrobials should always be based on diagnostic testing rather than empirical use. As with any animal, the results of culture and sensitivity diagnostic testing are ideal to identify the pathogenic organism and the appropriate antimicrobial drugs with which to treat the infection. When this is not available, the type of antimicrobial agent selected should be based on the spectrum of organism sensitivity, bioavailability, target tissue, and ease of administration.

Administration of the antimicrobial agents is sometimes a challenge. Injectable drugs are good for extremely ill patients. The quadriceps muscle is routinely used for intramuscular injections, but care should be taken to avoid the sciatic nerve. Intramuscular use should be limited because of the small muscle mass available for administration. Subcutaneous injections are another option available for administering treatment. Ferret skin can be quite tough, and scruffing is usually necessary for administration. Intravenous drugs are injected via the cephalic or saphenous veins with a 22- to 25-gauge butterfly catheter; however, anesthesia is almost always required if an indwelling catheter is not already in place.

When provided in a liquid form, oral medications are well suited for the ferret (Figure 13-7). Pills can be difficult to administer unless they are crushed and mixed with an oral supplement (e.g., Nutri-Cal) or treat. Liquid formulations that are bitter or unpalatable can also be a treatment challenge, as ferrets will readily object and excessively salivate. Pediatric formulations are much easier to give because their sweet taste increases palatability. The availability of compounding pharmacies and a variety of flavor additives offer additional options for liquid drug formulations that should be readily accepted by the ferret.

Emergency Drugs

The same drugs utilized for canine and feline emergencies may be used in the ferret when dosed by body weight. A complete physical assessment and history are necessary to determine an appropriate treatment plan. Initial diagnostic tests may also

cardiac failure. The recommended dosage for furosemide is 2.5 to 4 mg/kg every 8 to 12 hours. Digoxin, a positive inotrope, is integral to the treatment of dilated cardiomyopathy. The recommended initial dosage is 0.01 mg/kg orally every 24 hours and it should be increased to every 12 hours or decreased to once every other day, depending on the case. Just as in dogs and cats, serum digoxin levels should be checked 8 hours posttreatment to ensure that therapeutic levels are reached (0.8-2.0 ng/ml). The dosage is based on an estimated 75% lean body weight. Ferrets should be monitored for side effects that may be associated with digoxin therapy, such as cardiac arrhythmias, inappetence, vomiting, and diarrhea. Digoxin should not be used in ferrets that are azotemic or hypokalemic or have frequent ventricular arrhythmias. Nitroglycerin 2% ointment is also beneficial as a venodilator in the treatment of dilated cardiomyopathy. It can be applied to a shaved area of the skin on the inner thigh or pinna, 1/8 inch in size, every 12 to 24 hours. ACE-inhibitors are used to reduce arteriolar and venous tone, to increase cardiac output, and decrease edema; however, ferrets are sensitive to their hypotensive effects and thus require close monitoring. After an initial low dose, the amount can be increased if there is no ill response (e.g., inappetence, lethargy). The recommended dosage for enalapril is 0.25 0.5 mg/kg orally every 24 to 48 hours. Beta-adrenergic blockers and calcium channel blockers may be used for the treatment of hypertrophic cardiomyopathy. Their usage results in a decreased heart rate and increased diastolic filling. The recommended dose for atenolol is 6.25  mg/kg orally every 24 hours, and propranolol is 0.2 to 1 mg/kg orally every 8 to 12 hours. Diltiazem, a calcium channel blocker, is administered at a dose of 3.75 to 7.5 mg orally every 12 hours. Side effects of diltiazem include arrhythmias, lethargy, and inappetence. Supportive care for the cardiac patient includes oxygen supplementation for dyspnea, restricted activity, and a low salt diet. The prognosis for ferrets with cardiac disease is guarded to poor, even with intensive medical treatment.

THERAPEUTICS

Fluid Therapy

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Emergency Drugs

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Finally, analgesia should be provided, particularly with cases involving traumatic injuries, to reduce associated discomfort or pain.

**Blood Transfusions**

Ferrets lack detectable blood groups, an important consideration for patients (e.g., jills) with estrogen-induced bone marrow toxicity where multiple blood transfusions may be necessary. A study was conducted to test ferrets for naturally acquired or experimentally induced anti-erythrocyte antibodies, and no evidence could be found for the presence of anti-erythrocyte antibodies even after two blood transfusions from the same donors. The results of the study showed that there was little risk associated with blood transfusion in the ferret for up to three transfusions from the same donor, even without cross-matching. It is unknown, however, whether antibodies are produced after multiple transfusions.

An anesthetized large male ferret with a known medical history is the best blood donor from which 6 to 12 ml of blood can be safely collected. An anticoagulant such as an acid-citrate-dextrose solution in a ratio of 1 ml anticoagulant to 6 ml of blood should be used. A blood filter is not necessary, but a butterfly catheter introduced into the jugular vein facilitates blood collection from the donor and blood transfusion to the recipient. Infusion of the blood into the recipient should be done immediately under anesthesia by a slow bolus or infusion pump. A blood transfusion can also be administered via an intraosseous catheter.

**Nutritional Support**

Ill ferrets often are anorexic or have a reduced appetite and thus require nutritional support during hospitalization and treatment. The concern for the development of hepatic lipidosis or the exacerbation of hypoglycemia due to prolonged anorexia further emphasizes the need for nutritional supplementation. Enteral feeding is the preferred route of nutritional supplementation, and there are a variety of soft food preparations that can be administered via syringe. Hill’s Prescription Diet Canine/Feline a/d is often used and is readily accepted by the ferret; this diet can be mixed with Glucerna, a human diabetic supplement, for additional calories. Nutri-Cal can also be used as a supplement but should be limited in ferrets with insulinoma because of its high sugar content and the risk of reflex hypoglycemia. Soft foods should be fed 3 to 4 times daily at a volume of 2 to 5 ml each feeding. Once the ferret is showing improvement in appetite, the critical care diet can be left in the cage for the ferret to eat ad lib. If the patient is to be fed this diet over a long period of time, a formulated ferret diet should be soaked until soft and mixed with the critical care diet to ensure that the ferret is receiving adequate nutrition.

Parenteral nutrition may be necessary for some ferrets that refuse syringe feeding or who suffer from GI disease characterized by malabsorption. A total nutrient admixture (TNA) of lipid, dextrose, amino acids, electrolytes, vitamins, and minerals can be compounded to provide

Facilitate the selection of a therapeutic option. When treating a ferret with life-threatening conditions, cardiopulmonary resuscitation may be necessary, and the same protocols used for cats should be followed. Cardiopulmonary stimulating drugs should be administered in conjunction with manual resuscitation. Epinephrine can be used to stimulate the heart beat at a dosage of 0.4 mg/kg diluted in saline and administered intratracheally or 0.2 mg/kg IV, IO, or intracardiac. For the bradycardic patient, atropine is given at a dosage of 0.05 mg/kg IV or 0.10 mg/kg intratracheally. Respiration can be stimulated using doxapram at 1 to 2 mg/kg IV. Diazepam should be used to control seizures at an initial dose of 1 to 2 mg IV to effect. Dexamethasone is appropriate for the treatment of shock, whereas nonsteroidal antiinflammatory drugs may be utilized for trauma.

Fluids are also very important when treating the emergency ferret case, particularly those suffering from shock or requiring CPR. An emergency fluid rate for the ferret is 70 ml/kg/hr. Once the patient has been stabilized, the fluid rate can be reduced appropriately. Ferrets presenting in a hypoglycemic state characterized by collapse require immediate IV administration of dextrose. A slow bolus of 50% dextrose should be given until the ferret is responsive. The initial bolus dose should be followed up with the administration of fluid (e.g., LRS, Normosol) containing 5% dextrose and the initiation of prednisone to increase the blood glucose level. Blood glucose should be monitored regularly during treatment.

Close monitoring of the emergency patient for changes in its condition is required to determine treatment response. An external heat source is often needed to supplement and maintain a stable body temperature. Nutritional support should also be considered, as ill ferrets are often anorectic. Finally, analgesia should be provided, particularly with cases

*Figure 13-7* Scruffing the ferret with the nose directed upward facilitates the administration of oral medication.
parenteral nutrition. Administration should be via infusion pump through a silicone elastomer or polyurethane jugular catheter (Cook Veterinary Products, Bloomington, IL).

**SURGERY**

**Anesthesia**

Producing anesthesia in the ferret is very much like that of the dog and cat. A preanesthetic work-up consisting of a physical exam, CBC, and serum biochemistry panel is recommended for all ferrets, to reduce or eliminate the risks associated with anesthesia when underlying disease is present. Like dogs and cats, ferrets should be fasted before an anesthetic procedure. Because of the rapid transit time of the ferret gastrointestinal tract, fasting should be no longer than 8 hours in the young ferret and 4 hours in the older ferret. A shorter fasting time is of particular importance in middle-aged to geriatric ferrets because hypoglycemia secondary to insulinoma is a risk.

Either injectable drugs or gas inhalants may be used; however, gas anesthesia is preferred, particularly in the ill ferret. The ferret may be premedicated with a sedative or induced with a gas anesthetic via face mask or induction chamber. Induction via gas inhalant can be accomplished with flow rates of 5% isoflurane or 7% sevoflurane. Tracheal intubation is fairly easy in the ferret, and can be facilitated using a laryngoscope. Laryngospasm should not interfere with intubation; lidocaine can be used to minimize laryngospasm should they occur. A 2- to 3.5-mm endotracheal tube can be used and attached to a nonrebreathing system with a semi-open circuit. Most ferret patients are maintained on 3% isoflurane or 5% sevoflurane with an oxygen flow rate of 1 L/min.

An intravenous catheter should be placed in the ferret for any surgical procedure. The cephalic, lateral saphenous, or jugular veins may be accessed for intravenous catheterization. Ferrets have very tough skin, and a small stab incision adjacent to the vein may aid in placement of the catheter. Because of ferrets’ small body size, fluid loss should be closely monitored and replaced as needed. Ferrets with insulinoma should receive fluids containing 2.5% to 5% dextrose to prevent hypoglycemia.

Because of their large surface area to volume ratio, ferrets can lose body heat very quickly under anesthesia and are subject to hypothermia. Close monitoring of the body temperature and maintenance of body heat throughout the anesthetic procedure is important to keep the patient stable and to decrease recovery time. Minimizing the duration of anesthesia will also minimize the loss of body heat. There are several different devices that may be used to maintain a ferret’s body temperature during an anesthetic event, including a convective warm air blanket system, warm water circulating heating pad, heat lamp, or hot water bottle. Warm air will be trapped under the drapes and towels of a fully prepared surgical patient. Warm flush and intravenous fluids should also be used, when needed, to maintain body heat.

Close monitoring of the ferret during anesthesia can be accomplished in several ways. Depth of anesthesia may be assessed through the palpebral reflex or toe pinch. The cardiac rate and rhythm should always be monitored; monitoring is easily accomplished through the use of an ultrasonic Doppler, direct auscultation, or ECG. Pulse oximetry is also a good tool for monitoring the heart rate, as well as blood oxygen saturation. This may be applied to the tail or any of the paws. It may be necessary, however, to shave the area of contact to ensure an accurate measurement.

Recovery from anesthesia is normally quite smooth. Again, even after anesthesia is discontinued, it is important to maintain body heat to reduce recovery time. Close monitoring and IV access should continue until the ferret completely recovers. Since analgesia provided by the anesthetic gas subsides once the vaporizer is turned off, supplemental pain management should be provided before recovery in the form of butorphanol or buprenorphine to provide postsurgical comfort for the patient. Flunixin meglumine can also be used pre- and postoperatively to reduce pain and inflammation associated with surgery.

**Surgery**

Surgery in the ferret follows the same guidelines and principles as that for the dog and cat. Many of the surgical procedures are carried out in the same manner, with slight alterations in technique to accommodate anatomic differences. In the United States, ferrets are typically descended and spayed or neutered at an early age at the facility where they are born; therefore, these procedures are not routinely performed in private practice. Intact ferrets should be spayed or neutered before 6 to 8 months of age if they are not intended for breeding. In female ferrets this practice reduces the risk of hyperestrogenemia, and in males it reduces aggression as well as the musky odor produced by the sebaceous glands. The technique for both of these procedures follows that for the cat.

Anal sacculectomy (descenting) can be done at the time of neutering. It is important to note that this procedure does not eliminate the musky odor produced by the sebaceous glands. The anal sacs are 10 to 20 mm in length and are located on either side of the anus at the 4 and 8 o’clock positions. The duct openings should be identified at the mucocutaneous junction, and a circumferential incision 2 to 3 mm from the opening should be made. The duct and sacs are removed utilizing sharp and blunt dissection, carefully avoiding rupture during the process. Should the sac rupture during the procedure, the site should be flushed with saline, and a close inspection for complete removal of any remaining material should be made. A draining tract can form at the site if the anal sac is not removed intact. The incisions can be left open or can be closed with a single 5-0 absorbable intradermal suture.

In middle-aged to older ferrets, surgery for the treatment of insulinoma or adrenal gland disease becomes much more common. Abdominal surgery in adult ferrets should include complete exploration of the abdominal organs for evidence of disease. Tissue biopsies should be collected from suspect organs. The pancreas should always be palpated, as nodules are often difficult to visually identify. If multiple small nodules are
present on a lobe of the pancreas, a partial pancreatectomy is indicated. When larger, single nodules are identified, a nodectomy can be performed. Ferrets tolerate these procedures well and do not succumb to episodes of pancreatitis secondary to manipulation and trauma of pancreatic tissue.

The adrenal glands should always be palpated thoroughly at surgery. Both are located craniomedially to the kidneys; however, the right adrenal gland is also situated close to the caudal vena cava and below the caudal tip of the caudate lobe of the liver. Abnormal adrenal glands may be enlarged, irregular, firm, or discolored yellow or brown. The right gland is typically more difficult to remove due to its close proximity to the caudal vena cava. Removal of the adrenal glands can be done by bluntly dissecting the entire gland from the surrounding fat and ligating the adrenolumbar vessel, which is located on the ventral surface of the gland. Gel sponges can be placed to provide hemostasis for hemorrhage from the surrounding fat. When removing the right gland, care should be taken to avoid tearing the vena cava. Hemoclips can be applied to the longitudinal border of the vein as it borders the adrenal gland, allowing for safe trimming of the adrenal gland away from the vessel. Alternatively, the adrenal capsule can be incised and the gland removed from within.

Any tissues removed during abdominal surgery should be submitted for histopathologic examination. Again, complete examination of the entire abdomen for evidence of disease should be performed during any abdominal surgery. The abdomen can be closed using 4-0 absorbable suture for the linea and 5-0 absorbable suture for an intradermal layer. Skin sutures are not necessary. Ferrets usually do not chew at the incision, so further protection of the incision is not a concern. Follow-up evaluation of both the patient and the postoperative healing process should be scheduled 7 to 10 days following the procedure.

Bowel marrow aspirates are indicated in ferrets with anemia, thrombocytopenia, or hematopoietic neoplasia. The procedure is similar to that used with cats. The iliac crest, proximal femur, and humerus are all bone marrow collection sites. After aseptic preparation of the proximal femur, a small stab incision can be made over the greater trochanter to facilitate placement of a 20-gauge, 1.5-inch spinal needle into the marrow cavity. While stabilizing the femur in one hand, the veterinary surgeon should direct the needle into the cavity just medial to the greater trochanter. Once the needle has been seated, a 6-ml syringe can be attached and used for aspiration. Negative pressure should be limited to prevent blood contamination of the sample.

### Zoonoses

There are certain diseases of ferrets that deserve recognition for their zoonotic potential. Some of these diseases were described previously in the chapter (e.g., influenza, rabies, *Sarcoptes scabiei*, dermatophytosis, *Giardia*). Influenza is the only disease with documented ferret-to-human transmission. However, influenza is more commonly transmitted from people to ferrets. There have been no documented cases of human-acquired rabies from a ferret, but care must be taken when a suspect ferret rabies case is hospitalized. Client education of the zoonotic potential of infections such as scabies and ringworm is important, as these diseases are often treated at home. Handling should be restricted to those individuals providing treatment. Children and immunocompromised individuals should not handle the ferret during the course of treatment for scabies or ringworm. *Cryptosporidium parvum* is also a zoonotic concern, particularly for the immunocompromised pet owner, given its tendency to infect a variety of species. Ferrets are susceptible to several bacterial diseases (e.g., salmonellosis, listeriosis, tuberculosi, leptospirosis, campylobacteriosis), which may have zoonotic potential as well. When treating an ill ferret, proper hygiene and disinfection should be a routine practice in the veterinary clinic so as to prevent disease transmission among animals and caretakers. Early recognition of disease and client communication are important steps in reducing the risk of transmission and ensuring prompt treatment to those already exposed.

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