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# Basic Approach to Veterinary Care of Ferrets

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The approach to preventative medicine and basic veterinary care in ferrets is very similar to that used in dogs and cats. Special equipment needs are minimal, and pet ferrets can be easily incorporated into a general small animal practice. However, there are unique aspects of handling, restraint, and clinical and treatment techniques used in ferrets. For procedures not discussed here, modify techniques used in other small animals by using instrumentation appropriate for the ferret's small size and choosing appropriate sedation or anesthesia to facilitate the procedure while minimizing stress or discomfort in the ferret.

## RESTRAINT AND PHYSICAL EXAMINATION

### Restraint

Most ferrets are docile and can be easily examined without assistance. However, an assistant is usually needed when taking the rectal temperature, when administering injections or oral medications, or if an animal tends to bite. Young ferrets often nip, and nursing females and ferrets that are handled infrequently may bite. Ferrets often bite without warning. Therefore always ask the owner if the ferret bites before handling it and take precautions accordingly. Obtain the rabies vaccination history before physical examination. Be aware that rabies protocols for animal bites from vaccinated and unvaccinated ferrets differ by locale. Ferrets that are prone to biting and are not currently vaccinated for rabies may need to be sedated for procedures requiring restraint.

Depending on the ferret's disposition, several basic manual restraint methods can be used for examination. For tractable animals, lightly restrain the ferret on the examination table. Examine the mucous membranes, oral cavity, head, and skin. Then pick the ferret up and support its body with one hand while using the other hand to auscultate the thorax and palpate the abdomen. For an active animal or one that bites, scruff the ferret and suspend it with all four legs off the table (Fig. 2.1). Most ferrets become relaxed with this hold, and the veterinarian can examine the oral cavity, head, and body; palpate the abdomen; vaccinate; and clean the ears. However, even scruffing may not work for fractious animals. To restrain a ferret for a procedure, hold it firmly by the scruff of its neck and around the hips without pulling the legs back. Most ferrets struggle if their legs are extended by pulling on the feet. Some animals can be distracted during a procedure by feeding a meat-based canned food or a small amount of a supplement such as FerreTone (8-in-1 Pet Products, Islandia, NY) by syringe. For very fractious or anxious animals or for procedures requiring lengthy restraint, light sedation or anesthesia may be indicated (see Chapter 37).

### Physical Examination

Most ferrets strenuously object to having their temperature taken with a rectal thermometer, and a temperature taken after a ferret struggles may be artificially high. Therefore measure the rectal temperature early in the physical examination with a



**Fig. 2.1** Restrain an active ferret by scruffing the loose skin on the back of the neck. The ferret will relax and allow you to palpate the abdomen or administer a vaccine.

flexible digital thermometer that is well lubricated. The normal rectal temperature of a ferret is 100.5°F to 102.5°F (38.0°C to 39.2°C); however, a mean of 102°F (38.8°C), with a wider range of 100°F to 104°F (37.8°C to 40.0°C), is also reported.<sup>22</sup>

Physical examination of a ferret can be performed quickly and efficiently if a few simple guidelines are followed. Observe the attitude of the animal. Ferrets may sleep in the carrier in the veterinary office; however, once awakened for the examination, a ferret should be alert and active. Assess hydration by observing the skin turgor of the eyelids, tenting of the skin at the back of the neck, and moistness of the oral mucous membranes. Note that skin turgor can be difficult to evaluate in a cachectic animal. Estimate the capillary refill time by digitally pressing on the gingiva.

Examine the eyes, nose, ears, and facial symmetry. Cataracts can develop in both juvenile and adult animals. Retinal degeneration occurs in ferrets and may be indicated by abnormal pupil dilation. Inspect for nasal discharge, and ask the owner about any history of sneezing or coughing. The ears may have a brown waxy discharge, but excessive brown exudate may indicate infestation with ear mites. Observe the facial symmetry. Although uncommon, salivary mucoceles occur in ferrets and present as a unilateral swelling on the side of the face, usually in the cheek or temporal area (see [Chapter 3](#)).

The teeth should be clean and the gingiva pink. Dental tartar is common in pet ferrets, possibly related to feeding kibble instead of natural prey.<sup>13</sup> Plaque buildup may be exacerbated by feeding a diet with a high mineral content.<sup>26</sup> Remove excess dental tartar by prophylactic techniques used in dogs and cats, and recommend measures to prevent tartar buildup. A pet toothpaste can be used to decrease the rate of calculus formation.<sup>26,28,38</sup> Gingivitis is a common sequela of excessive dental tartar. Ferrets often break off the tip of one or both canine teeth, and the broken tooth may appear dark. However, ferrets rarely exhibit sensitivity

associated with a fractured canine. If the ferret exhibits sensitivity when the tip of the canine is probed, recommend a root canal or extraction, depending on the degree of tooth damage (see [Chapter 36](#)). Bruxism often indicates gastrointestinal discomfort.

Palpate the submandibular, axillary, popliteal, and inguinal lymph nodes. Nodes should be soft and may sometimes feel enlarged in overweight animals because of surrounding fat. Any firmness or asymmetry warrants fine-needle aspiration or biopsy. If two or more nodes are enlarged and firm, a diagnostic workup is indicated.

Auscultate the heart and lungs in a quiet room. Ferrets have a rapid heart rate (180 to 250 beats/min) and often a pronounced sinus arrhythmia. If a ferret is excited and has a very rapid heart rate, subtle murmurs may be missed. Valvular disease, cardiomyopathy, and congestive heart failure are seen in ferrets, and any murmur or abnormal heart rhythm should be investigated further (see [Chapter 5](#)). The ferret's normal respiratory rate is 33 to 36 breaths/min (see [Chapter 6](#)).

Palpate the abdomen while either scruffing the ferret or supporting it around the thorax with one hand. This allows the abdominal organs to displace downward, facilitating palpation. If the history is consistent with an intestinal foreign body or urinary blockage, palpate gently to avoid causing iatrogenic injury, such as a ruptured bladder. Palpate the cranial abdomen, paying attention to the presence of gas or any firm, irregularly shaped material in the stomach area, especially in ferrets with a history of vomiting, melena, or chronic weight loss. The spleen is often enlarged, which may or may not be significant, depending on other clinical findings (see [Chapter 5](#)). A very enlarged spleen may indicate systemic disease or, very rarely, idiopathic hypersplenism, and further diagnostic workup is warranted.

Examine the genital area, observing the size of the vulva in females. Vulvar enlargement in a spayed female is consistent with either adrenal disease or an ovarian remnant; the latter is rare. Examine the preputial area and size of the testicles of male ferrets; preputial and testicular tumors are sometimes seen.

Check the fur for evidence of alopecia. Tail tip alopecia is common and may be an early sign of adrenal disease. Symmetric, bilateral alopecia or thinning of the fur that begins at the tail base and progresses cranially is a common finding in ferrets with adrenal disease. Examine the skin on the back and neck for evidence of scratching. Pruritus is common with adrenal disease and also may indicate ectoparasites (e.g., fleas or *Sarcoptes scabiei*). Palpate and visually examine the skin thoroughly for masses. Mast cell tumors are common and are variable in size. Often, the fur around a mast cell tumor is matted with dried blood from the animal's scratching. Other types of skin tumors, such as sebaceous adenomas and basal cell tumors, are also common (see [Chapter 9](#)). Perform an excisional biopsy of any lump found on the skin.

## PREVENTIVE MEDICINE

Young, recently purchased ferrets need serial canine distemper vaccinations until they are 14 weeks of age.<sup>3</sup> Rabies vaccines should be given annually beginning at 3 months of age.<sup>14</sup> Ferrets should be examined annually until they are 4 to 5 years

of age; then, older animals may need examinations twice yearly because of the high incidence of metabolic disease and neoplasia. Annual blood tests are recommended for older animals. Measure the blood glucose concentration twice yearly in healthy middle-aged and older ferrets; more-frequent monitoring is needed in ferrets with insulinoma. Abdominal ultrasound scanning or an endocrine panel is indicated in ferrets with thinning fur on the tail or other clinical signs suggestive of adrenal disease (see Chapter 7). Testing for infectious diseases may be warranted, especially in new or young ferrets that will be introduced into a multi-ferret household or those that are taken to ferret shows. Ferrets can be tested for Aleutian disease virus and ferret enteric coronavirus by polymerase chain reaction testing (Michigan State University, Diagnostic Center for Population and Animal Health, [www.animalhealth.msu.edu](http://www.animalhealth.msu.edu); Veterinary Molecular Diagnostics, [www.vmdlabs.com](http://www.vmdlabs.com); Zoologix, [www.zoologix.com](http://www.zoologix.com)). Serologic tests for Aleutian disease by enzyme-linked immunosorbent assay (ELISA) and counterimmunoelectrophoresis are also available (see Chapter 5).

## Vaccinations

### Canine Distemper

Ferrets must be vaccinated against canine distemper virus (CDV). Currently, one vaccine is approved by the U.S. Department of Agriculture for use in ferrets: PureVax Ferret (Boehringer Ingelheim Animal Health, Duluth, GA). PureVax is a canarypox-vectored recombinant vaccine that does not contain complete CDV or adjuvants; thus, post-vaccination risks are reduced. This product has a wide safety margin and has proved effective in protecting ferrets against CDV.<sup>69</sup> Although supply from the manufacturer has been intermittently problematic in the United States, the vaccine is available.

Canine distemper vaccines that were previously used in ferrets but are now discontinued include Fervac-D (United Vaccines, Inc, Fitchberg, WI), a modified-live virus vaccine propagated in avian cell lines, and Galaxy D (Schering-Plough Animal Health/Merck), a modified-live virus vaccine derived from the Onderstepoort canine distemper strain and attenuated in a primate cell line. Galaxy vaccines are now marketed under the Nobivac (Merck Animal Health, Madison, NJ) trade name. In a safety and efficacy study, Galaxy D proved effective in preventing canine distemper in young ferrets challenged after serial vaccination.<sup>74</sup>

Other canine distemper vaccines have been used off-label in ferrets in countries other than the United States or when PureVax has been unavailable. Recombitek CDV (Boehringer Ingelheim Animal Health) is also a recombinant canarypox vaccine approved for use in dogs that has been used in ferrets. This CDV vaccine is marketed in several multivalent combinations including CDV with parvovirus: a monovalent product is not available in the United States. Nobivac Puppy-DPv (Merck Animal Health) is a modified live virus canine distemper vaccine combined with parvovirus vaccine, a virus that does not affect ferrets. Although these vaccines have been used clinically in ferrets, their safety and efficacy in ferrets have not been studied. A CDV vaccine approved for use in mink (Distemink; United Vaccines Inc, Fitchberg, WI) is available in 250-dose vials only. Because of the possibility of vaccine-induced disease, especially

in immunosuppressed or sick ferrets, avoid using multivalent canine vaccines and do not use modified live CDV vaccines of ferret-cell or low-passage canine-cell origin.

Standard vaccination protocols for canine distemper in ferrets have been based on serial vaccinations of young ferrets at 6, 10, and 14 weeks,<sup>3</sup> with annual boosters. However, recent data suggest a modified vaccine schedule consisting of two initial vaccines with less-frequent boosters is effective. In an efficacy study of 150 ferrets, 90% of ferrets that were initially vaccinated at 9 weeks and given a booster vaccine between 14 and 16 weeks of age with one of three commercial vaccines (Purevax Ferret, Fervac-D, or Galaxy D) maintained protective antibody titers of >1:50 for at least 3 years.<sup>72</sup> The three commercial vaccines did not differ in efficacy of eliciting protective titers. Therefore an initial vaccination protocol of two vaccinations, starting at 8 to 9 weeks of age and separated by 4 weeks, followed by a booster every 3 years, should suffice in most cases (D. Perpiñan, personal communication, May 2018). For ferrets at high risk of contracting canine distemper or when highly pathogenic strains of CDV are circulating, consider more-intensive vaccination protocols. If the ferret is first vaccinated after 3 to 4 months of age, a series of two vaccinations separated by 4 weeks is sufficiently protective (D. Perpiñan, personal communication, May 2018).<sup>29</sup>

### Rabies

All ferrets should be vaccinated against rabies.<sup>14</sup> Two inactivated (killed) rabies vaccines are approved for use in ferrets in the United States: Imrab-3 or Imrab-3 TF (Boehringer Ingelheim Animal Health) and Defensor 1 or Defensor 3 (Zoetis, Parsippany, NJ). Inactivated vaccines are effective at producing immunity for at least 1 year.<sup>63</sup> Current recommendations are to vaccinate healthy ferrets at 3 months of age at a dose of 1 mL administered subcutaneously (SC). Give booster vaccinations annually. Titers develop within 30 days of rabies vaccination.<sup>63</sup>

Clinical signs of rabies in ferrets can vary. In studies of experimentally induced rabies in ferrets, clinical signs range from restlessness, apathy, and paresis to ascending paralysis, ataxia, cachexia, bladder atony, fever, hyperactivity, tremors, and paresis.<sup>8,48</sup> Mean incubation period in experimental studies varies from 28 to 33 days.<sup>48,49</sup> Virus is present in the brain tissue and salivary glands of inoculated ferrets, and virus is shed in the saliva 2 to 6 days after onset of illness.<sup>48,49</sup> Ferrets are at least 25 times less susceptible than skunks to rabies infection when fed mice carcasses infected with rabies virus.<sup>5</sup> Survival and clearance of rabies virus infection was reported in one ferret experimentally infected with rabies virus of skunk origin. The ferret initially exhibited hindlimb paralysis that resolved to paraparesis. No virus antigen was found at necropsy 6 months after inoculation.<sup>24</sup>

Ferrets are considered currently immunized 28 days after the initial rabies vaccination and immediately after a booster vaccination.<sup>14</sup> If a healthy pet ferret bites a person, current recommendations of the Compendium of Animal Rabies Prevention and Control are to confine and observe the animal for 10 days, during which the ferret should not be vaccinated.<sup>14</sup> Any illness that develops during observation should be reported immediately to the local health department. If signs suggest rabies, the ferret must be euthanized, and protocols for rabies evaluation

followed. For a ferret with a current vaccine status exposed to a possible rabid animal, recommendations are to revaccinate the ferret within 96 hours of exposure and then keep the ferret under the owner's observation and care for 45 days. Exposed ferrets that are overdue for a booster rabies vaccination should be evaluated on a case-by-case basis by the health department. An unvaccinated animal that is exposed to a rabid animal or a stray ferret that bites a person should be euthanized immediately and submitted for rabies testing. See the website of the Centers for Disease Control and Prevention ([https://www.cdc.gov/rabies/specific\\_groups/veterinarians/](https://www.cdc.gov/rabies/specific_groups/veterinarians/)) or the National Association of Public Health Veterinarians (<http://www.nasphv.org/documentsCompendia.html>) for specific guidelines.

### Vaccine-Associated Adverse Events

In ferrets, adverse events associated with vaccination are primarily type I hypersensitivity reactions or anaphylaxis.<sup>43</sup> Ferrets with mild reactions may exhibit pruritus and skin erythema. More severe reactions are typified by vomiting, diarrhea, piloerection, hyperthermia, cardiovascular collapse, or death.

Vaccine reactions are most common after canine distemper vaccination but may also occur after rabies vaccination. In a study of vaccine-associated adverse events in 3857 ferrets in the United States, the incidence of adverse events associated with rabies vaccine alone, canine distemper vaccine alone, and rabies and canine distemper vaccines together were 0.51%, 1.0%, and 0.85%, respectively, with no significant difference among groups.<sup>45</sup> However, occurrence of a vaccine-associated adverse event was significantly associated with the cumulative number of canine distemper vaccinations, with an 80% increase in risk of an adverse event with each additional distemper vaccine. The canine distemper vaccines used in this cohort of ferrets were PureVax Ferret and Fervac-D; the two vaccines were grouped collectively in the analysis, and the incidence of adverse events associated with individual vaccines was not reported. All reactions occurred immediately after vaccination and most commonly consisted of vomiting and diarrhea. In another study of 143 ferrets, the incidence of adverse events after administering either canine distemper (5.9%) (Fervac D), rabies (5.6%) (Imrab-3), or both vaccines (5.6%) did not differ significantly between groups.<sup>23</sup> In a 2001 report of 83 vaccine reactions in ferrets reported to the U.S. Pharmacopeia Veterinary Practitioners' Reporting Program, 65% involved administration of FerVac D, 24% involved concomitant administration of FerVac D and Imrab 3, and 11% involved administration of Imrab alone (PureVax was not approved for use at the time these data were collected).<sup>43</sup> According to Merial's (now Boehringer Ingelheim) product information, the incidence of vaccine reactions with PureVax is 0.3%. No adverse events were reported in an efficacy study of vaccination of 150 ferrets with either PureVax Ferret, Fervac-D, or Galaxy D.<sup>72</sup> Surveillance of vaccine-associated adverse events relies on voluntary reporting by practitioners.<sup>43</sup> Vaccine-associated adverse events can be reported to the Center for Biologics, U.S. Department of Agriculture (<https://www.aphis.usda.gov/aphis/ourfocus/animalhealth/veterinary-biologics/adverse-event-reporting>).

Always follow the manufacturer's instructions for vaccine administration, and inform the owner of the possibility of an

adverse reaction before vaccinating. Because most reactions occur almost immediately after vaccination, have the owner monitor the ferret in the waiting area for 30 minutes or more after vaccination with any product.

If a ferret has an adverse reaction, administer an antihistamine (e.g., diphenhydramine hydrochloride, 0.5 to 2.0 mg/kg intravenously [IV] or intramuscularly [IM]), epinephrine (0.01 mg/kg IV, IM or intratracheally), or a short-acting corticosteroid (e.g., dexamethasone sodium phosphate, 1 to 2 mg/kg IV or IM), and give supportive care.

For any biologic product, veterinarians must assess risk versus benefit of vaccination. The treatment options for ferrets that have had a vaccine reaction are to administer diphenhydramine (2 mg/kg orally [PO] or SC) at least 15 minutes before vaccination or not to vaccinate if exposure risk is minimal.

Vaccine injection-site sarcomas have been described in ferrets.<sup>46,47</sup> In one report, 7 of 10 fibrosarcomas in ferrets were from locations used for vaccination.<sup>46</sup> Fibrosarcomas had similar histologic, immunohistochemical, and ultrastructural features as those reported for feline vaccine-associated sarcomas. In cats, adjuvanted vaccines are most likely to be involved in tumor development; however, no definitive association was made between the fibrosarcoma and the type of vaccine in ferrets. Ferrets appear less prone than cats to development of vaccine-induced tumors.

### Parasites

#### Endoparasites

Gastrointestinal parasitism is most common in young or recently purchased pet ferrets and is relatively uncommon in mature ferrets in the United States. In a survey of ferrets that were either privately owned or in pet shops in Italy, 14 of 50 (28%) were positive for ancylostomids (hookworms) and one (2%) was positive for *Sarcocystis*.<sup>17</sup> Ferrets can be intermediate hosts or vectors of parasites from other natural hosts. Protozoan parasites are occasionally seen. Therefore perform routine fecal flotations and direct fecal smears for all young or recently acquired ferrets.

Coccidiosis (*Isospora* species) usually is seen in young ferrets, which shed oocysts between 6 and 16 weeks of age.<sup>4</sup> Infection is often subclinical, although ferrets occasionally may have loose stool or bloody diarrhea. Coccidiostats, such as sulfadimethoxine and amprolium, are effective and safe, and treatment should be continued for at least 2 weeks. Coccidia in ferrets may cross-infect dogs and cats; therefore check other pets in the household for coccidia and treat as needed.

Giardiasis is occasionally seen in ferrets. Results of studies on molecular characterization and host specificity of *Giardia duodenalis* isolates from pet ferrets vary. In one study, genetic sequences of giardia isolates from ferrets were similar to those of giardia associated with human infections.<sup>55</sup> Results of another study showed genetic sequences of giardia differed in ferrets and people and other mammals, suggesting that *Giardia* isolates from ferrets may be host specific.<sup>2</sup> *Giardia* can be detected by identifying cysts or trophozoites in a fresh fecal smear or zinc sulfate flotation, or by fecal ELISA. Treat ferrets with giardiasis with metronidazole (20 mg/kg PO every 12 hours for 5 to 10 days) or fenbendazole (50 mg/kg PO every 24 hours for 3 to 5 days).

Cryptosporidiosis is described primarily in young ferrets.<sup>60</sup> Infection is associated with the ferret genotype of *Cryptosporidium parvum* and therefore is an unlikely source of human infection.<sup>1</sup> Infection is usually subclinical and, although most ferrets recover within 2 to 3 weeks, can persist for months in immunosuppressed animals. Oocysts of *Cryptosporidium* are small (3–5  $\mu\text{m}$ ) and difficult to detect but can be found in fresh fecal samples examined immediately after acid-fast staining.<sup>4,60</sup> Various drugs, including azithromycin, tylosin, and nitazoxanide, are used for treatment in dogs and cats, but efficacy in ferrets is not known.<sup>64</sup>

Heartworms (*Dirofilaria immitis*) can cause disease in ferrets. Ferrets that are housed outdoors in heartworm-endemic areas are most susceptible to infection; however, all ferrets in endemic areas should be treated with heartworm preventive (see Chapter 5 and Appendix).

### Ectoparasites

Ear mites (*Otodectes cynotis*) are common in ferrets, but affected animals may not exhibit pruritus or irritation. This mite species also infects dogs and cats, and animals in households with multiple pets can transmit mites to other animals. A red-brown, thick, waxy discharge in the ear canal and pinna characterizes infection. A direct smear of the exudate reveals adult mites or eggs. Because ferrets normally have brown ear wax, the color or appearance of debris in the ear canal is not pathognomonic for mites. At the initial examination, check for ear mites and do follow-up checks at the annual examination in ferrets kept in multiple-pet households. Several products, including selamectin, are effective in treatment (see Chapter 9).

Flea infestation (*Ctenocephalides* species) is most common in ferrets kept in households with dogs or cats. Ferrets with chronic infestations can become severely anemic. Check ferrets during the physical examination for signs of fleas or flea dirt. Treat infested animals with products safe for use in cats, and institute flea control measures (see Chapter 9). Ticks are rarely seen on domestic ferrets, and Lyme disease in ferrets has not been reported.

## HOSPITALIZATION

Ferrets can be hospitalized in standard hospital cages with some adaptations. Ferrets are agile escape artists and often can squeeze through vertical cage bar openings on standard hospital cages. For housing ferrets, use only commercial cages with small spacing between bars or use cages with attached Plexiglass fronts at least half the height of the cage door or higher to prevent escape. Small animal intensive care cages or incubators also can be used to house ferrets and are especially useful for animals that need supplemental heat or oxygen. Closely monitor the temperature in these cages when using supplemental heat to prevent hyperthermia or hypothermia. The cage should be large enough to accommodate a sleeping area and an area for defecation and urination. Ferrets typically do not soil their sleeping area, even when very sick.

All ferrets like to burrow and should be given opportunity to do so while hospitalized. Clean towels or a mound of shredded paper make excellent burrowing material. Take care with

plastic-backed underpads, which ferrets may chew and ingest. Small padded pet beds and fleece pet “pockets” work well as sleeping areas.

Provide water in either water bottles or small weighted bowls. Before hospitalization, ask the owner which type of watering system the ferret is accustomed to. Ferrets can be finicky eaters and should be fed their regular diet while hospitalized, if possible. Otherwise, feed a very palatable ferret food or a premium high-protein cat/kitten kibble. For animals that are anorectic, force-feed a high-calorie semisolid food or supplement until the animal is eating on its own (see later discussion).

## CLINICAL AND TREATMENT TECHNIQUES

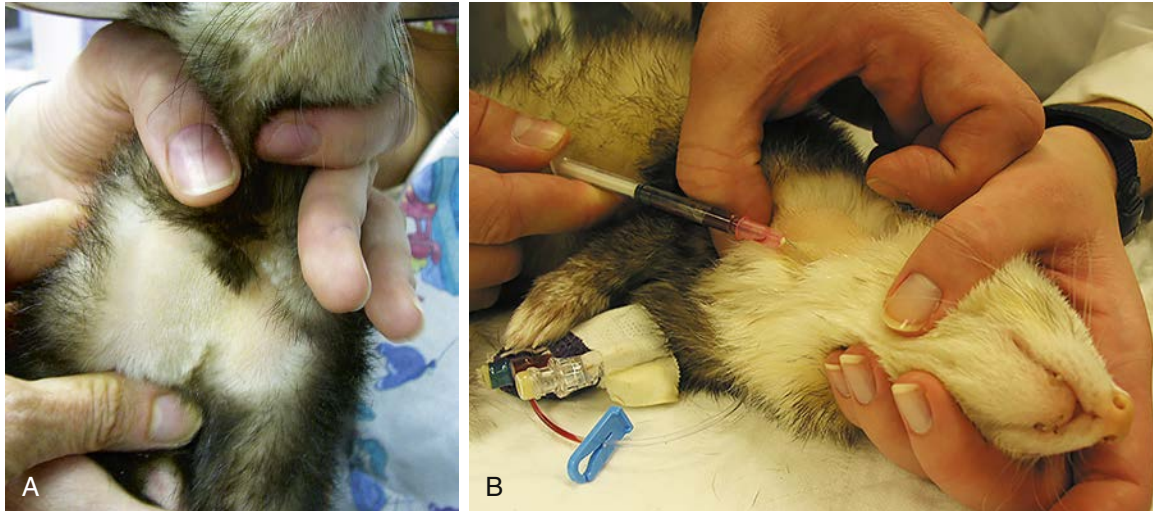
### Venipuncture

Most veterinary laboratories offer small mammal hematologic and biochemical panels that require 1.0 mL or less of blood. In-clinic, point-of-care analyzers require very small sample sizes (usually 100  $\mu\text{L}$ ). The blood volume of healthy ferrets is approximately 40 mL in average-sized females weighing 750 g and 60 mL in males weighing 1 kg.<sup>22</sup> Up to 10% of the blood volume can be safely withdrawn at one time in a normal ferret; however, collect only the minimum amount needed for analysis. Repeated blood drawing can contribute to anemia in sick animals hospitalized for long periods.

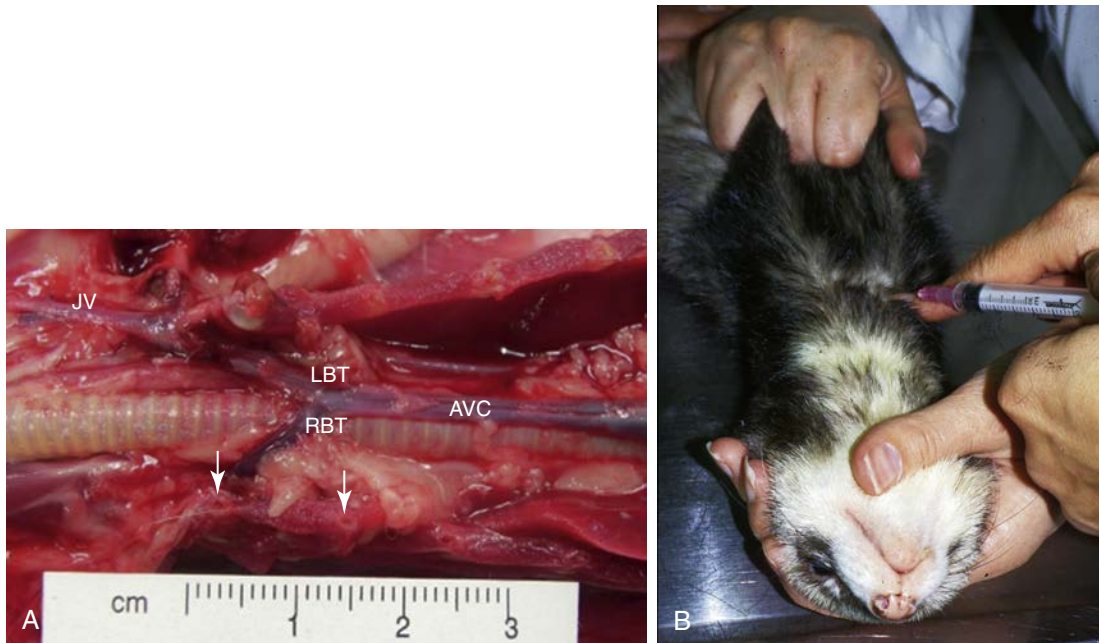
Obtaining a blood sample from a ferret is relatively easy. Venipuncture usually can be done with manual restraint, but some veterinarians prefer sedating or anesthetizing especially active animals. Several venipuncture sites are readily accessible; the technique and site chosen depend on how much blood is needed and the availability of assistants for restraint. Anesthesia or sedation can be used if assistants are unavailable. If needed, ferrets often can be distracted during restraint for venipuncture by offering semisolid food or a product such as FerreTone (8-in-1 Pet Products) by syringe. Avoid using supplements with corn syrup or other sugars, because this will affect blood glucose levels, and collect blood for glucose determination or other fasting samples before offering food.

The blood collection technique can affect hematologic test results. Isoflurane anesthesia can cause decreases in all hematologic values beginning at induction of anesthesia and reaching maximal effects at 15 minutes after induction.<sup>41</sup> Both isoflurane and sevoflurane can cause a decrease in packed cell volume.<sup>32</sup> Therefore hematologic results of blood samples collected while a ferret is anesthetized must be interpreted carefully (see Chapter 39).<sup>41</sup>

Two sites are commonly accessed to obtain large blood volumes in ferrets. Jugular venipuncture can be accomplished by extending the ferret's forelegs over the edge of a table and the neck up, or by restraining the ferret in lateral recumbency (Fig. 2.2). Have a second assistant restrain the ferret's hind end on the table to prevent twisting, or wrap the lower body in a towel. Use a 25-gauge needle bent slightly to a 20-degree angle with a 1- to 3-mL syringe for venipuncture in most ferrets; a 22-gauge needle can be used in large males. Shave the neck at the venipuncture site to enhance visibility of the jugular vein. The vein is relatively superficial and is located more laterally in the neck than it is in dogs or cats. Once the needle



**Fig. 2.2** Restraint for Jugular Venipuncture in a Ferret. (A) Shave the neck to improve visibility of the jugular vein in the lateral neck. The ferret can be restrained with the legs pulled down and the head back; after the vein is punctured, the head can be “pumped” up and down slowly to facilitate blood flow. (B) A sedated ferret placed in lateral recumbency for jugular venipuncture.



**Fig. 2.3** (A) Dissection of the thoracic cavity of a ferret illustrating the site for blood collection by the anterior vena cava technique. The sternum and ventral ribs are removed. The site of venipuncture is either the right brachiocephalic trunk (RBT) or left brachiocephalic trunk (LBT) or the anterior vena cava (AVC), depending on the point of entry and depth of penetration (see marker). The jugular vein (JV) is usually lateral and cranial to the venipuncture site. The base of the first two ribs is shown by arrows. (B) A ferret is restrained for venipuncture of the anterior vena cava. Both forelegs are pulled back, hindlegs are restrained, and the neck is extended.

is inserted, the blood should flow easily into the syringe; if the neck is overextended and the head is arched back, the blood may not flow readily from the vein. Relax the hold on the head or gently “pump” the vein by moving the head slowly up and down to enhance blood flow into the syringe. With ferrets that resist limb extension, a towel-wrap technique can be used. Scruff the ferret with its front legs extended caudally against the ventral thorax and wrap the animal’s body firmly with a towel from the base of the neck down. Have an assistant restrain the toweled ferret in dorsal recumbency

while scruffing the neck or holding the head. However, with very fractious animals, even this technique may be difficult.

The second venipuncture site from which to obtain large blood samples is the cranial vena cava. The site of venipuncture is the anterior vena cava or the right or left brachiocephalic trunk, depending on the point of entry and the depth of needle penetration (Fig. 2.3, A). This technique is relatively safe in ferrets because of the long anterior vena cava and the caudal location of the heart in the thoracic cavity, which is approximately 3 cm from the thoracic inlet.

TABLE 2.1 Reference Intervals for Hematologic Values in Ferrets

Value	Combined Sex <sup>a</sup>	Combined Sex <sup>b</sup>	ALBINO <sup>70</sup>		FITCH <sup>33</sup>	
			Male <sup>c</sup>	Female	Male <sup>d</sup>	Female
Hematocrit, %	36–48	—	44–61	42–55	46–57	47–51
Hemoglobin, g/dL	12.2–16.5	13.9–21.9	16.3–18.2	14.8–17.4	15.2–17.7	15.2–17.4
Red blood cells, $\times 10^6/\mu\text{L}$	7.01–9.65	7.4–13	7.30–12.18	6.77–9.76	—	—
Reticulocytes, %	—	—	1–12	2–14	—	—
White blood cells, $\times 10^3/\mu\text{L}$	4.3–10.7	3.0–16.7	4.4–19.1	4.0–18.2	5.6–10.8	2.5–8.6
Neutrophils, %	18–47	17–82	11–82	43–84	—	—
cells/ $\mu\text{L}$	—	900–7400	—	—	616–7020	725–2409
Lymphocytes, %	41–73	13–81	12–54	12–50	—	—
(cells/ $\mu\text{L}$ )	—	600–10,500	—	—	1728–4704	1475–5590
Monocytes, %	0–4	0–6.5	0–9	2–8	—	—
(cells/ $\mu\text{L}$ )	—	0–500	—	—	0–432	100–372
Eosinophils, %	0–4	0–5.7	0–7	0–5	—	—
(cells/ $\mu\text{L}$ )	—	0–700	—	—	112–768	50–516
Basophils, %	0–2	0–1.4	0–2	0–1	—	—
(cells/ $\mu\text{L}$ )	—	0–200	—	—	0–112	0–172
Bands, cells/ $\mu\text{L}$	—	0–100	—	—	0–972	0–248
Platelets, $\times 10^3/\mu\text{L}$	200–459	172–1281	297–730	310–910	—	—
Mean corpuscular volume, fL	50–54	50–61	—	—	—	—
Mean corpuscular hemoglobin, g/dL	15–18	—	—	—	—	—
Mean corpuscular hemoglobin concentration, g/dL	32–35	29–34	—	—	—	—

<sup>a</sup>Combined male and female pet ferrets ( $n = 60$ ). From Cray C, Avian and Wildlife Laboratory, Miller School of Medicine, University of Miami, Miami, FL.

<sup>b</sup>Data converted from SI units; modified from Hein, et al.<sup>27</sup> Blood was collected from the lateral saphenous vein of clinically healthy ferrets ( $n = 105$  to  $n = 106$ ) (age 11 weeks to 9 years; intact males and females, neutered males, spayed females, mixed haircoat) manually restrained.

<sup>c</sup>Intact males.

<sup>d</sup>Castrated males.

However, rare instances of hemorrhage into the anterior thoracic cavity can occur. For this technique, restrain the ferret on its back with the forelegs pulled caudally and the head and neck extended (Fig. 2.3, B). With manual restraint, two assistants are usually needed, one to restrain the forelegs and head and the other to restrain the rear just cranial to the pelvis. Use a 25-gauge needle with an attached 1-mL or 3-mL syringe; insert it into the thoracic cavity between the first rib and the manubrium at an angle 30 to 45 degrees to the body. Direct the needle toward the opposite rear leg or most caudal rib and insert it almost to the hub. Pull back on the plunger as the needle is slowly withdrawn until blood begins to fill the syringe. If the ferret struggles, quickly withdraw the needle and wait until the ferret is quiet before making a second attempt. In very fractious or active ferrets, jugular venipuncture or use of tranquilization are safer choices to avoid lacerating the vessels.

The lateral saphenous or cephalic vein can be used if only a small amount of blood is needed to measure a packed cell volume or blood glucose level. To prevent collapse of the vein during venipuncture, use an insulin syringe with an attached 27- or 28-gauge needle. The saphenous vein lies just proximal to the tarsus on the lateral surface of the leg; the cephalic vein is in the same anatomic location as in a dog. Before venipuncture, shave the fur from the area to enhance visibility of the vein.

Venipuncture of the tail artery is possible but rarely used in pet ferrets.<sup>9</sup> Venipuncture at this site is painful and requires anesthesia. Insert a syringe with a 21-gauge needle into the ventral midline of the tail directed toward the body. Once the artery is entered 2 to 3 mm deep into the skin, slowly withdraw the plunger until blood fills the syringe. Apply pressure to the venipuncture site for 2 to 3 minutes after withdrawing the needle.

### Reference Intervals

Most commercial veterinary diagnostic laboratories provide laboratory-specific reference intervals for ferret hematologic and biochemical values (see Chapter 39). Published sources of reference intervals for both laboratory and pet ferrets are available.<sup>22,27,33,67,70</sup> Reference intervals for hematologic, biochemical, and plasma electrophoresis values in ferrets from select sources are listed in Tables 2.1, 2.2, and 2.3.

Coagulopathy is relatively rare in ferrets, and blood coagulation panels are done infrequently in clinical practice. Currently, reference values from commercial veterinary diagnostic laboratories for blood coagulation assays are not available. Results of several research studies investigating blood coagulation values in ferrets have been published.<sup>7,16,37,68,70</sup> Values determined by coagulation assays can vary significantly by methods used and by laboratory.<sup>7,37</sup> Table 2.4



TABLE 2.2 Reference Intervals for Biochemical Values in Ferrets

Analyte	Plasma <sup>a</sup>	SERUM	
		Albino <sup>b</sup>	Mixed Haircoat <sup>c</sup>
Alanine aminotransferase, U/L	65–128	—	49–243
Albumin, g/dL	2.5–4.0	2.6–3.8	2.8–4.4
Alkaline phosphatase, U/L	25–60	9–84	13–142
Amylase, U/L	26–36	—	19–62
Aspartate aminotransferase, U/L	70–100	28–120	40–143
Bilirubin, total, mg/dL	0.2–0.5	<1.0	0.0–0.2
Blood urea nitrogen, mg/dL	18–32	10–45	13–47
Calcium, mg/dL	8.1–9.5	9.0–11.8	8.0–10.4
Carbon dioxide, mmol/L	22–29	16–25	—
Cholesterol, mg/dL	119–163	64–296	93–274
Chloride, mmol/L	—	106–125	108–120
Creatinine, mg/dL	0.2–0.5	0.4–0.9	0.3–0.9
Creatine phosphokinase, U/L	55–93	—	94–731
Glucose, mg/dL	80–117	94–207	54–153
Gamma glutamine transferase, U/L	8–34	—	0–14
Lactate dehydrogenase, U/L	200–1400	—	154–1781
Phosphorus, mg/dL	5.1–6.5	4.0–9.1	3.1–9.6
Potassium, mmol/L	4.5–6.1	4.5–7.7	3.9–5.9
Sodium, mmol/L	142–148	137–162	138–143
Total protein, g/dL	4.5–6.2	5.1–7.4	5.5–7.8
Triglycerides, mg/dL	30–140	—	44–248
Uric acid, mg/dL	1.3–1.9	—	—

<sup>a</sup>Combined male and female pet ferrets (n = 60). From Cray C, Avian and Wildlife Laboratory, Miller School of Medicine, University of Miami, Miami, FL.

<sup>b</sup>Combined values of male (n = 40) and female (n = 24) ferrets.<sup>70</sup>

<sup>c</sup>Data converted from SI units; modified from Hein et al.<sup>27</sup> Blood was collected from the lateral saphenous vein of clinically healthy ferrets (n = 94 to n = 109) (age 11 weeks to 9 years; mixed intact males and females, neutered males, spayed females; mixed haircoat type) that were manually restrained. Serum was assayed using the Hitachi 911 chemistry analyzer (Roche Diagnostics, Indianapolis, IN).

TABLE 2.3 Reference Intervals for Plasma Protein Electrophoresis in Ferrets

Analyte	Combined Sex <sup>a</sup>
Albumin, g/dL	2.50–3.31
α-1 globulin, g/dL	0.33–0.56
α-2 globulin, g/dL	0.36–0.60
β globulin, g/dL	0.83–1.20
γ globulin, g/dL	0.31–0.81
Albumin/globulin ratio	1.05–1.33

<sup>a</sup>Combined male and female ferrets (n = 60). From Cray C, Avian and Wildlife Laboratory, Miller School of Medicine, University of Miami, Miami, FL.

contains blood coagulation values determined in normal ferrets that can be used as guidelines in the absence of reference intervals specific to a laboratory or to coagulation analyzer equipment.

### Intravenous Catheters

Indwelling intravenous catheters can be placed in the lateral saphenous or cephalic vein (Fig. 2.4). Jugular vein catheters are

difficult to place and are rarely used. Except in very depressed animals, catheters are placed with the ferret sedated or anesthetized. Applying a topical anesthetic on the venipuncture site approximately 30 to 60 minutes before the procedure may facilitate catheter placement. To place the catheter, shave and aseptically prepare the area, then puncture the skin with a 20- or 22-gauge needle, taking care to avoid the vein. Introduce a short 22-, 24-, or 26-gauge over-the-needle catheter through the skin puncture into the vein, and secure the catheter routinely. Monitor ferrets with indwelling catheters to prevent the fluid line from tangling, and check the leg distal and proximal to the catheter frequently for soft tissue swelling. Most ferrets do not chew a catheter once it is placed and do not require an Elizabethan collar.

In ferrets that are collapsed with poor blood pressure or in young or very small ferrets, attempts to place an intravenous catheter may be unsuccessful. An intraosseous catheter can be placed in these animals. The proximal tibia is the most common site for intraosseous catheter placement in small mammals,<sup>34</sup> but the proximal femur can also be used and allows for a greater range of movement. Unless the ferret is very depressed, anesthesia is required to place the catheter. Sterilely prepare the insertion site

**TABLE 2.4 Blood coagulation values of normal ferrets**

Analyte	Takahashi et al <sup>68</sup>	Benson et al <sup>7</sup>	Lewis <sup>37</sup>
Activated partial thromboplastin time, sec	17.0 ± 1.2 (15.3–18.7)	18.7 ± 0.9 <sup>a</sup> (17.5–21.1) 18.1 ± 1.1 <sup>b</sup> (16.5–20.5)	18.4 ± 1.4
Antithrombin activity, %	—	96 ± 12.7 (69.3–115.3)	—
Fibrinogen, mg/dL	486.7 ± 97.9 (382.5–658.3)	107.4 ± 19.8 (90.0–163.5)	—
Clotting time, min	—	—	2.0 ± 0.5 <sup>c</sup> 3.0 ± 0.9 <sup>d</sup>
Prothrombin time, sec	11.3 ± 0.4 (10.9–12.0)	12.3 ± 0.3 <sup>a</sup> (11.6–12.7) 10.9 ± 0.3 <sup>b</sup> (10.6–11.6)	10.3 ± 0.1
Thrombin time, sec	13.7 ± 2.7 (9.4–16.9)	—	28.8 ± 8.7

<sup>a</sup>Measured by fibrometer.

<sup>b</sup>Measured by automated system.

<sup>c</sup>Glass tubes.

<sup>d</sup>Silicone tubes.

and infiltrate the area with 1% to 2% lidocaine (maximum dose, 1 mg/kg).<sup>34</sup> Insert a 20- or 22-gauge, 1.5-inch spinal needle into the marrow cavity. Alternatively, use a 20- or 22-gauge hypodermic needle with a surgical steel wire inserted into the lumen to prevent a bone plug from occluding the needle during insertion.<sup>52</sup> The intraosseous catheter should occupy approximately 30% to 70% of the marrow cavity at the narrowest portion.<sup>34</sup> Administer drugs through intraosseous catheters in small volumes with minimal pressure to prevent leakage from the insertion site. If possible, change to an intravenous catheter as soon as the animal is rehydrated or blood pressure improves. Intraosseous catheters should not be left in place for more than 72 hours.<sup>34</sup>

Vascular access ports can be placed when repeated vascular access is required for any reason, such as for chemotherapy.<sup>59</sup> The technique used to place the catheter and port has been described and illustrated.<sup>53</sup>

## Fluid Therapy

Hospitalized ferrets usually require fluid therapy to maintain hydration and correct dehydration. Daily fluid requirements of ferrets have not been determined; however, calculating fluid requirements at a rate of 60 to 70 mL/kg per day appears to be adequate for maintenance. One source estimates daily water consumption of adult ferrets as 75 to 100 mL/day.<sup>44</sup> Provide additional fluids to compensate for ongoing fluid loss and to correct dehydration calculated as a percentage of the body weight.

Intravenous fluids are preferred in ill animals. If possible, administer intravenous fluids by continuous-rate infusion. Alternatively, divide the calculated daily fluid volume into two or three doses and administer by a Buretrol (Baxter Healthcare, Glendale, CA) or syringe pump. Depending on the clinical condition of the ferret, supplements and drugs can be added to fluids



**Fig. 2.4** Placing an indwelling catheter in the cephalic vein of a ferret. The hair over the vein is shaved and the vein is held off. A 24-gauge, 0.75-inch intravenous catheter is introduced into the vein and taped in place.

by using the same criteria and calculations as for dogs and cats. Although subcutaneous fluids can be given, ferrets react painfully to subcutaneous administration, and adequate restraint is needed. Administer subcutaneous fluids in the loose skin along the back and dorsal cervical area, dividing the calculated daily fluid volume into doses given two or three times daily.

Colloids are effective in improving intravascular fluid volume and oncotic pressure in ferrets that are hypoproteinemic or in shock. Dosage and administration are like those used in other small animals (see [Chapter 41](#)).

## Antibiotic and Drug Therapy

Antibiotics and other therapeutic agents are usually given at dosages like those in cats per kg of body weight (see Appendix). In hospitalized animals with an indwelling catheter, give medications intravenously if possible. However, monitor the leg where the catheter is placed carefully for phlebitis and cellulitis, particularly when caustic medications are administered. Antibiotics can be administered IM; however, if treatment continues over several days, subcutaneous administration is preferred in cachectic animals because of the limited muscle mass. Pills are very difficult to administer to ferrets; therefore oral medications are most easily given compounded into liquid form. Ferrets generally accept chicken and beef flavors of compounded medications but do not like the taste of fish flavors.

## Pain Management

Pain management is important in the postoperative period, with diseases that create significant discomfort (such as gastrointestinal ulceration), and for traumatic injuries (see [Chapter 37](#)). Ferrets in pain may exhibit tachypnea, a stiff gait, a strained facial expression, teeth grinding, shivering, half-closed eyelids, aggression, focal muscle fasciculation, hiding, general malaise, bristling of tail fur, and appear “tucked” in the abdomen.<sup>42,71</sup> Many analgesic agents are used effectively in ferrets, including opioids,  $\alpha$ -2 agonists, nonsteroidal antiinflammatory drugs (NSAIDs), and local anesthetics.<sup>30</sup> Clinically, buprenorphine,

butorphanol, or meloxicam or combinations thereof are most commonly used for hospitalized animals and outpatients (see [Chapter 37](#) and [Appendix](#)). Although no studies have evaluated efficacy of meloxicam for analgesia in ferrets, a meloxicam dose of 0.2 mg/kg in ferrets achieves plasma concentrations considered effective in other companion animals.<sup>12</sup>

Ferrets are sensitive to acetaminophen toxicity.<sup>15</sup> The activity of uridine 5'-diphospho (UDP)-glucuronosyltransferase in their livers compares with that of cats. Acetaminophen glucuronidation is slower in ferrets than in other nonfelid species. Unlike cats, however, no genetic mutations are associated with this slow metabolism, and the exact cause is unknown. Ibuprofen can be toxic in ferrets at high doses,<sup>11</sup> and accidental ibuprofen ingestion of 220 mg/kg can cause death.<sup>62</sup> Clinical signs of toxicosis are depression, coma, ataxia, recumbency, tremors, weakness, and death.<sup>62</sup> Therefore avoid acetaminophen in ferrets and use NSAIDs with caution. Do not use NSAIDs in ferrets being treated with a corticosteroid for insulinoma or other disease.

Epidural administration of analgesics before surgery appears to be effective in controlling postoperative pain in ferrets undergoing procedures involving the abdomen, spine, pelvis, hind legs, tail, and perineum (see [Chapter 37](#)).<sup>18,66</sup> The technique has been well described in ferrets and is similar to that used in other small animals.<sup>18,25</sup> Epidural injection is contraindicated in cases of coagulopathy, sepsis, hypovolemia, skin infection, and local fractures.<sup>18</sup>

Be careful in the immediate postoperative period when opioids, such as butorphanol or buprenorphine, are used. In cats, as well as in other species, opioids including hydromorphone, butorphanol, and buprenorphine are associated with an increase in body temperature.<sup>58</sup> Opioid analgesics also can cause pronounced sedation, and ferrets can remain very lethargic and immobile for long periods. Because of these two factors, immobile ferrets can overheat quickly if a heating lamp or other focused heat source is used during anesthetic recovery. Therefore closely monitor the body temperature of any immobile or lethargic ferret given opioids or sedatives to prevent overheating when using heat lamps or forced-air warming devices.

## Nutritional Support

Many sick ferrets are either cachectic or hypoglycemic or have minimal body fat and require nutritional support. Products formulated as recovery diets for carnivores are available and readily accepted by most ferrets (Carnivore Care, Oxbow Animal Health, Murdock, NE; Emeraid Carnivore, EmerAid, Cornell, IL). Ferrets can be syringe-fed meat-based soft foods marketed for hospitalized dogs and cats (Maximum-Calorie Plus, The Iams Company, Mason, OH; Canine/Feline a/d, Hill's Pet Nutrition, Topeka, KS). Do not offer supplement gels that contain corn syrup because of the high sugar content. Force-feed anorectic ferrets as much as they will accept comfortably, usually 8 to 12 mL syringe fed three or four times daily. Ferrets that develop a taste for the food may eat it directly from a bowl.

Ferret owners often prepare homemade diets of "duck soup" or "chicken gravy" to nurse their pets at home. Many different recipe variations are available, and most are based on whole chicken with additives ranging from beef fat, dog kibble, nutritional supplement gels, or brewer's yeast to Echinacea capsules.

The "duck soup" variations all provide a soft, porridge-consistency food that is usually readily eaten by sick and convalescing ferrets. Some recipes are very high in fat and carbohydrates. Unless the homemade diets are based on or used with a commercial ferret diet, they should not be used long term because of possible nutritional imbalances and deficiencies.

Although seldom used clinically, esophagostomy feeding tubes can be placed in ferrets to manage debilitated animals over the long term. The technique is like that used in cats.<sup>21</sup> Gastric feeding tubes have been placed in ferrets both experimentally and clinically.<sup>6,10</sup> In a study of 14 ferrets, gastrostomy tubes were placed percutaneously by a nonendoscopic technique. A gastrostomy tube was placed and maintained successfully in a ferret after surgical repair of an esophageal perforation caused by an esophageal foreign body.<sup>10</sup>

Total nutrient admixtures have been formulated to provide partial parenteral nutrition to ferrets.<sup>52,61</sup> Depending on the osmolarity of the solution, parenteral nutrition solutions can be delivered via a central, peripheral, intraosseous, or intraperitoneal catheter; however, the relatively high protein requirements of ferrets usually result in a solution of 600 to 800 mOsm/L, which should be administered into a large (central) vein.<sup>61</sup>

## Urine Collection and Urinalysis

Urine samples can be collected by cystocentesis or by free catch after natural voiding or gentle manual expression of the bladder. The techniques for manually expressing the bladder and cystocentesis are the same as those used in dogs and cats. Anesthetize fractious ferrets to avoid trauma to the thin bladder wall. Use a 25-gauge needle for cystocentesis.

Reference values for urinalysis are listed in [Table 2.5](#). In one study, the reference range for urine pH in ferrets was reported as 6.5 to 7.5; however, urine pH can vary according to the diet. The normal urine pH in ferrets fed a high-quality, meat-based diet is approximately 6.0.

## Urinary Catheterization

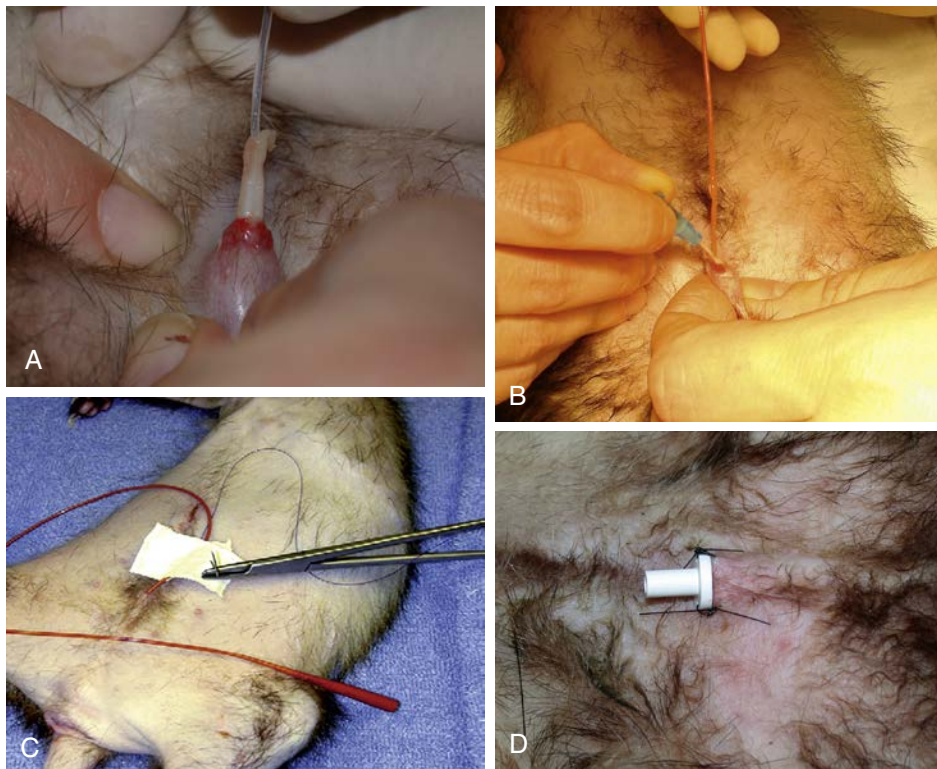
Urinary catheterization is commonly indicated in male ferrets, but the procedure can be challenging. Although techniques have been described for both sexes,<sup>40</sup> clinical indications to place a urinary catheter in females are rare.

For females, tranquilize or anesthetize the ferret, then position it in ventral recumbency with the rear quarters elevated with a rolled towel. With a vaginal speculum, locate the urethral opening in the floor of the urethral vestibule, approximately 1 cm cranial to the clitoral fossa. Introduce a 3.5-French (Fr), red rubber urethral catheter fitted with a wire stylet into the urethral orifice.

In male ferrets, the urethral opening is very small and is located on the ventral surface of the penis, proximal to the J-hook in the end of the os penis. Use a 3.0- or 3.5-Fr polytetrafluoroethylene, silicone,<sup>35</sup> or polyurethane urinary catheter (Slippery Sam Tomcat Urethral Catheter, Surgivet, Smiths Medical, Dublin, OH; Tomcat Urethral Catheter, Surgivet; Tomcat/Small Animal Urinary Catheter, Mila International Inc., Florence, KY). Alternatively, use a 3.5-Fr rubber feeding catheter; estimate the length of the catheter that must be inserted to reach the bladder before placing (see also [Chapter 4](#)). If using a long rubber

TABLE 2.5 Reference Values for Urinalysis in Ferrets

Parameter	MALES		FEMALES		COMBINED SEX
	Mean $\pm$ SD	Range	Mean $\pm$ SD	Range	Mean $\pm$ SD
Volume, mL/24hr	26 <sup>70</sup>	8–48 <sup>70</sup>	28 <sup>70</sup>	8–140 <sup>70</sup>	24.9 $\pm$ 14.3 <sup>20</sup>
pH	6.2 $\pm$ 0.1 <sup>22</sup>	6.5–7.5 <sup>70</sup> 6.0–6.5 <sup>22</sup>	6.3 $\pm$ 0.3 <sup>22</sup>	6.5–7.5 <sup>70</sup> 6.0–6.5 <sup>22</sup>	—
Protein, mg/dL	9.6 $\pm$ 1.4 <sup>22</sup>	7–33 <sup>70</sup>	7.6 $\pm$ 1.2 <sup>22</sup>	0–32 <sup>70</sup>	—
Specific gravity	1.051 $\pm$ 9 <sup>19</sup>	1.034–1.070 <sup>19</sup>	1.042 $\pm$ 8 <sup>19</sup>	1.026–1.060 <sup>19</sup>	—
Creatinine clearance, mL/min/kg					
Exogenous	—	—	—	—	3.3 $\pm$ 2.2 <sup>20</sup>
Endogenous	—	—	—	—	2.5 $\pm$ 0.9 <sup>20</sup>
Inulin clearance, mL/min/kg	—	—	—	—	3.0 $\pm$ 1.8 <sup>20</sup>



**Fig. 2.5** (A) The urethral catheter is introduced into the urethral opening proximal to the J-shaped tip of the os penis. (B) The urethral opening has been dilated by placing the tip of an intravenous catheter just inside the opening and flushing gently with saline solution. The lubricated end of a 3.5-Fr red rubber or urinary catheter is then introduced into the opening and the intravenous catheter is removed. (C) A 3.5-Fr red rubber catheter is sutured in place using butterfly tape (photo courtesy Dr. Marla Lichtenberger). (D) The hub of a Slippery Sam urinary catheter is sutured in place to the prepuce.

catheter, use a stylet or flexible wire to stiffen the catheter if needed; the stylet can be retracted slightly while passing the catheter, but be very careful when rounding the pelvic flexure to avoid perforating the urethra. Another option is to use a 20-gauge or 22-gauge, 8-inch jugular catheter with the stylet removed.<sup>52</sup> To pass the urinary catheter, aseptically prepare the preputial area, locate the urethral opening, and introduce the catheter tip (Fig 2.5, A). If the urethral opening is difficult to see, dilate the opening by passing a 24-gauge intravenous catheter just inside the tip of the urethra and flushing gently with saline solution (Fig 2.5, B). Slip the tip of the lubricated urinary catheter gently into the

dilated urethral opening alongside the intravenous catheter and, while gently flushing with saline solution, pass the catheter into the bladder. Often resistance is met at the pelvic flexure; if this occurs, try repeated gentle flushing and relubricating the catheter until it passes. Once in place, if using a red rubber catheter, place butterfly tape strips around the catheter just as it enters the urethra and at another point 3 to 5 cm distal, and suture these to the skin (Fig 2.5, C). If using a urethral catheter, suture the catheter hub to the prepuce (Fig 2.5, D). Attach a sterile urinary collection device and tape the tubing to the tail to further prevent tension. If needed, bandage the ferret's abdomen to minimize rotation of

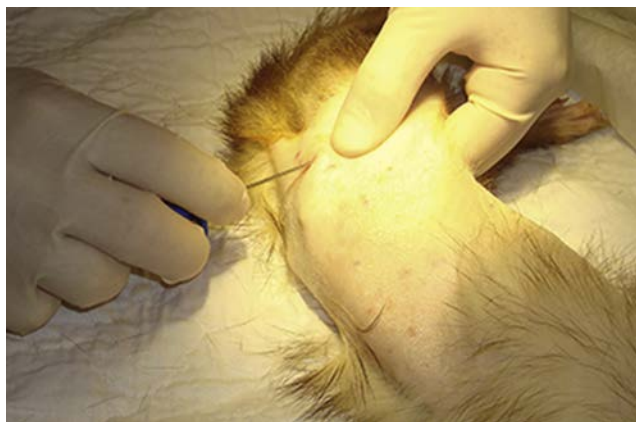
the catheter and to restrict the ferret from traumatizing it. Soft Elizabethan collars are needed in some ferrets to prevent chewing at the catheter. Maintain sterility of the collection system, and drain the bag by needle and syringe rather than opening the system (see also [Chapter 4](#)).

Temporary tube cystostomy has been used successfully to manage male ferrets with urinary obstruction caused by adrenal disease. In four ferrets treated surgically, a 5- or 8-Fr Foley catheter was placed in the bladder at the time of adrenalectomy and left in place for 5 to 14 days.<sup>50</sup> In these ferrets, immediate treatment of urinary blockage was by cystocentesis. A cystostomy catheter also can be placed by using interventional radiographic techniques. This is an option in obstructed ferrets in which a urethral catheter cannot be passed and surgery is considered high risk. A cystostomy catheter allows azotemic ferrets to be managed with diuresis before surgery; alternatively, in cases in which surgery is not an option, the catheter can remain in place pending response to medical management with leuprolide acetate.

### Blood Pressure Monitoring

Indirect blood pressure monitoring techniques, using both Doppler ultrasonography and oscillometric methods, have been described in ferrets.<sup>36,51,65,73</sup> However, both methods poorly approximate direct arterial blood pressure measurements. Indirect blood pressure readings may be inaccurate because the neonatal blood pressure cuff does not fit securely on the short legs of ferrets (Doppler method), and pressure changes of the tail artery may not be sufficiently high to be detected by the oscillometric system.<sup>51</sup> In one study, the indirect systolic blood pressure values measured by Doppler on the tail of ferrets measured 28 mmHg less than the direct arterial systolic blood pressure values.<sup>51</sup> In a study using 14 male ferrets that compared indirect blood pressure measurements on the tail, forelimb, and hindlimb using an oscillometric sphygmomanometer and a high-definition oscillometric monitor with direct arterial blood pressure measurements, measurements using the tail were considered most reliable.<sup>65</sup> However, the oscillometric sphygmomanometer consistently overestimated the systolic arterial pressure. Indirect measurements of systolic, mean, and diastolic arterial pressures were consistently higher during hypotensive states but substantially lower in hypertensive states than corresponding direct blood pressure measurements. In a study of 63 healthy ferrets, sedation with butorphanol (0.2 mg/kg IM) and midazolam (0.2 mg/kg IM) was found optimal to allow indirect blood pressure measurement.<sup>73</sup> Reference values for indirect blood pressure measured with the cuff placed at the base of the tail were 94 to 155 mmHg systolic, 69 to 109 mmHg mean, and 51 to 87 mmHg diastolic arterial pressure. Be aware of the above-described inconsistencies of indirect compared with direct blood pressure measurements and interpret clinical results carefully.

In clinical situations, indirect blood pressure is most useful for evaluating changes in blood pressure from a known baseline or for surgical monitoring of general trends rather than for exact blood pressure measurement. The Doppler method of indirect blood pressure measurement is most commonly used in ferrets. Shave the hair on the ventral tail and place a no. 1 (3 to 6 cm) cuff on the most proximal part of the tail and attach it to a sphygmomanometer. Place the



**Fig. 2.6** Collection of a bone marrow sample from the femur of an anesthetized ferret. The femur is stabilized while inserting a 20-gauge, 1.5-inch spinal needle medial to the greater trochanter.

Doppler transducer probe crystal with ultrasound gel on the shaved skin approximately 1 cm distal to the cuff and tape or hold in place. Alternatively, place the cuff just above the carpus or tarsus (overlying the radial artery on the front leg or the digital branch of the tibial artery on the rear leg, alternatively) or on the distal humerus.<sup>36</sup>

### Bone Marrow Collection

Evaluating a bone marrow sample is a valuable diagnostic tool for many disease conditions, including anemia, thrombocytopenia, pancytopenia, proliferative abnormalities, and suspected hematopoietic malignancies. Although the proximal femur is usually the most readily accessible site ([Fig. 2.6](#)), the iliac crest, tibial crest, and humerus can also be used to collect bone marrow samples. Anesthesia is necessary to aspirate the bone marrow or perform a core biopsy. With the ferret in lateral recumbency, shave and aseptically prepare the area around the collection site. For the proximal femur,<sup>54</sup> make a small incision over the greater trochanter. Stabilize the femur with one hand while inserting a 20-gauge, 1.5-inch spinal needle into the bone, medial to the greater trochanter. Use steady pressure and an alternating rotating motion to advance the needle into the marrow cavity. Withdraw the stylet and attach a 6- to 12-mL syringe to the needle to aspirate the marrow, stopping suction as soon as the sample is visible (to prevent blood contamination). To collect a core biopsy sample, use the same technique, but use a 1.5-inch, 18-gauge needle in place of the spinal needle (see also [Chapter 8](#)). Collect samples from alternate sites by using the same basic technique.

### Blood Transfusion

Blood transfusions may be needed in ferrets that are anemic from chronic disease, blood loss, or estrogen toxicosis, or in ferrets that are thrombocytopenic. As in other species, evaluate the need for a transfusion based on the packed cell volume or platelet count and clinical status of the ferret. Consider a transfusion if the packed cell volume is 25% or less in a ferret that exhibits clinical signs of anemia or requires surgery, or if a ferret is thrombocytopenic and exhibits ecchymosis, petechiation, or bleeding.

Ferrets lack detectable blood groups, and risk of transfusion reaction is minimal, even without cross-matching.<sup>39</sup> Because of a

greater blood volume, large male ferrets are preferred over females as blood donors. Depending on the size of the donor ferret, 6 to 12 mL of blood can be safely collected for transfusion. Collect blood into an anticoagulant such as acid-citrate-dextrose or citrate-phosphate-dextrose-adenine (CPDA) at a ratio of 1 mL of anticoagulant to 6 to 9 mL of donor blood.<sup>31</sup> Ferret blood collected into CPDA at a 6:1 ratio has a shelf life of 7 days when stored at 4° C; after 7 days, deterioration of red blood cells (RBCs) causes a decrease in blood pH, glucose, and sodium and an increase in lactate and potassium.<sup>56</sup> Whenever possible, collect blood from donor ferrets shortly before transfusion. Always use a filter when transfusing whole blood, and use at least a 22-gauge catheter to prevent cell lysis during the transfusion. Intraosseous blood transfusions can be given to ferrets if an intravenous catheter cannot be placed.

### Splenic Aspiration

Splenic aspiration is a common diagnostic technique in ferrets with enlarged spleens (see Chapter 5). The technique is simple and can be done in unanesthetized ferrets; however, if a ferret is fractious, use an injectable sedative. An ultrasound-guided aspirate is preferred, especially if a splenic mass is present. Alternatively, palpate the abdomen and immobilize the enlarged spleen next to the body wall and aspirate directly. A positive aspirate appears bloody. The most common findings on cytologic examination of a splenic aspirate are extramedullary hematopoiesis and lymphoma.

### Cerebrospinal Fluid Tap

Analysis of cerebrospinal fluid (CSF) as a diagnostic tool is occasionally indicated in ferrets that present with neurologic signs. The volume of CSF fluid that can be removed safely is 0.26 mL/kg.<sup>57</sup> For a CSF tap, place the anesthetized ferret in lateral recumbency. Using a 25-gauge, 1.6-cm-long hypodermic needle, puncture the cerebromedullary cistern and allow free flow of the CSF fluid. In clinically normal ferrets, reference values for CSF tap are mean white blood cells (WBCs), 1.6 cells/ $\mu$ L (range 0–8 cells/ $\mu$ L); mean RBCs, 1041 cells/ $\mu$ L (range 0–11,560 cells/ $\mu$ L); and mean protein concentration, 31.4 mg/dL (range 28–68 mg/dL).<sup>57</sup> In a study of 42 ferrets in which a CSF tap was performed, RBCs of <100 cells/ $\mu$ L were obtained in 64% of cases, and the number of WBCs was significantly affected by blood contamination, but protein concentration was not.<sup>57</sup>

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