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Medical and Surgical Emergencies in Ferrets



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KEYWORDS

- Small mammals • Seizures • Hypoglycemia • Critical care • Congestive heart failure
- Trauma • Intoxication • Chylothorax

KEY POINTS

- Hypoglycemic seizure is one of the most common emergencies in ferrets.
- Primary hypoparathyroidism needs to be considered in seizing ferrets with low calcium, high phosphorus, and maintained renal function.
- Anemia is a common consequence of hyperestrogenism, which typically results from uncontrolled estrus in female ferrets or adrenal disease; currently, medical alternatives to gonadectomy and adrenalectomy should be considered.
- Gastrointestinal foreign bodies and biliary disorders are both common causes of acute abdomen in ferrets.
- Congestive heart failure is usually secondary to valvular disorder, atrioventricular block, dilated and restrictive cardiomyopathies, and hypertension and requires immediate medical treatment (eg, diuretics, thoracentesis).



Video content accompanies this article at <http://www.vetexotic.theclinics.com>

INTRODUCTION

Ferrets presented for an emergency should be immediately triaged. The cardiovascular (mucous membrane color, capillary refill time, and pulse rate and quality), respiratory (rate and effort), and central nervous (consciousness) systems should be assessed early.¹ If the ferret is considered unstable, further evaluation of vital physiologic parameters (blood pressure, rectal temperature, oxygen saturation of hemoglobin [SpO₂], electrocardiogram [ECG], and blood glucose) is required together with a prompt institution of treatment (**Fig. 1**). If the ferret is considered stable, further historical questioning and a complete physical examination may proceed.

The author has nothing to disclose.

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Fig. 1. Preliminary hospitalization approach to an unstable ferret (A). Notice SpO₂ measurement, oxygen, and IV fluid therapy from the cephalic vein. During triage, pulse is easily obtained by palpation of the femoral arteries (B).

SEIZURES

Seizures commonly occur in ferrets and may be consequent to a wide variety of causes. However, true spontaneous epileptic seizures have never been described in ferrets, and seizures are usually reactive, that is, caused by metabolic or toxic conditions.² Hypoglycemia is considered the most common condition causing seizures in ferrets; however, other conditions, including electrolyte disorders, intoxication, hepatic encephalopathy, hypothyroidism, uremic encephalopathy, hypoxia, and hyperglycemia, may also be the cause.³

Hypoglycemia

Hypoglycemic seizures are an extremely common emergency presentation in ferrets. Typically, hypoglycemia in ferrets is the consequence of hyperinsulinemia caused by pancreatic β -cell tumors (ie, insulinomas).⁴⁻⁶ Other causes that should be included in the differentials for hypoglycemia include anorexia, liver disorders, and hypoadrenocorticism.⁷ Ferrets with severe hypoglycemic crises are usually stuporous and may present with opisthotonus ([Video 1](#)) and nystagmus ([Video 2](#)). Often the crises are accompanied by vocalizations ([Video 3](#)).

Diagnosis of hypoglycemia is based on detection of a blood glucose level lower than 60 to 70 mg/dL.^{8,9} Although tempting for its easiness, diagnosis of hypoglycemia should never be based only on the use of portable blood glucose meters (PBGM). PBGM for use in humans unpredictably underestimate blood glucose in ferrets¹⁰ and have specificity for diagnosis of hypoglycemia in ferrets of 50%,⁹ which means that half of the ferrets in which the PBGM detect hypoglycemia are actually normoglycemic (false positives).⁹ PBGM developed for canine and feline patients (Alphatrak, Abbott, Abbott Park, IL) provide results that are more in agreement with laboratory analyzers.¹⁰ However, given the clinical importance of the diagnosis, these methods should be mainly used for screening and monitoring instead of for diagnosing. Instead, the diagnosis on presentation should be based on a hexokinase-based laboratory analyzer whenever possible. An empirical approach to the ferret presented with suspected hypoglycemic seizures is as follows:

- Placement of an intravenous (IV) catheter preferably in the cephalic vein ([Fig. 2](#)) under manual restraint. Alternatively, catheterize the saphenous or jugular vein ([Fig. 3](#)).

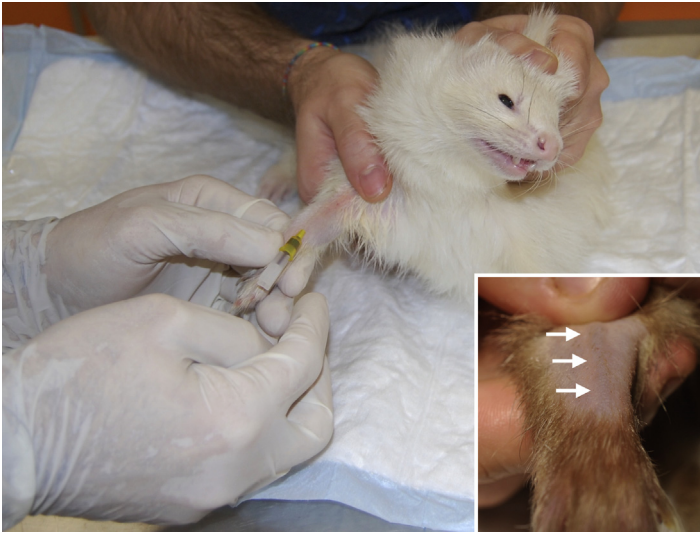


Fig. 2. The cephalic vein is the author's preferred site for placement of IV catheters in conscious ferrets. Inset: notice the straight course of the vein (arrows). (Courtesy of Nicola Di Girolamo, Rome, Italy.)

Intraosseous catheterization should be avoided, because with proper technique, IV catheterization is almost always feasible.

- Collect an adequate amount of blood from the catheter itself in a lithium-heparin-coated tube. Alternatively, obtain a blood sample to be placed in the collection tube under manual restraint (Figs. 4 and 5).
- Immediate measurement of glucose with a point-of-care device that uses the hexokinase method (eg, VetScan VS2, Abaxis, Darmstadt, Germany).
- Ideally, concurrently measure other electrolytes, including ionized calcium.
- If hypoglycemia is confirmed, slow administration of a bolus of 33% glucose solution or 50% dextrose solution (2–3 mL) followed by constant-rate infusion (CRI) of 5% glucose (10 mL/kg/h). Notice that there is potential risk of phlebitis by using high osmotic solutions.

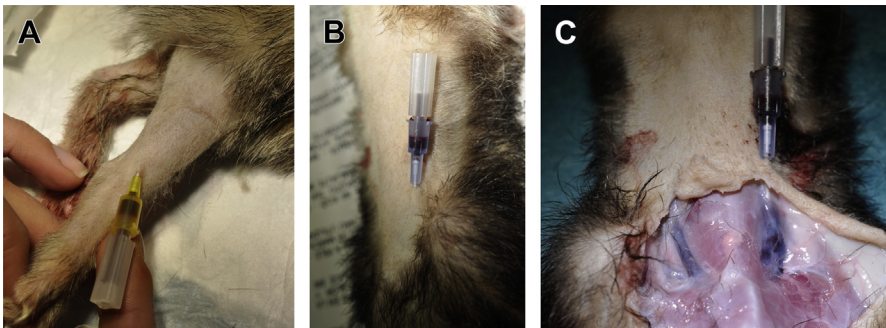


Fig. 3. Alternative sites for IV catheter placement: saphenous (A) and jugular vein (B). The anatomy of the jugular veins is showed in a ferret cadaver (C). Intraosseous catheters are avoidable in ferrets if proper technique for IV catheterization is used. (Courtesy of Nicola Di Girolamo, Rome, Italy.)



Fig. 4. Blood sampling from the cranial vena cava under manual restraint. Although it is a blind technique, the anatomic landmarks are well established. The needle should be inserted cranial to the first rib and lateral to the manubrium of the sternum. Inset: anatomy of the site in a ferret cadaver. Notice that the jugular veins merge into the cranial vena cava just below the first rib. Ca, caudal; Cr, cranial; CVC, cranial vena cava; J, jugular vein; T, trachea. (Courtesy of Nicola Di Girolamo, Rome, Italy.)

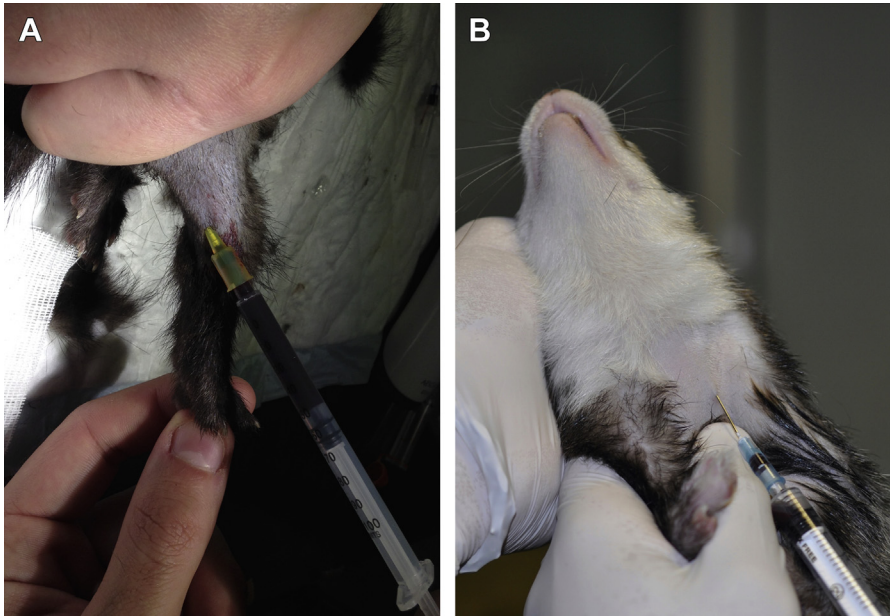


Fig. 5. Blood sampling from the saphenous (A) and the jugular (B) veins under manual restraint. (Courtesy of Nicola Di Girolamo, Rome, Italy.)

- If the seizures persist, a second bolus of glucose/dextrose solution and administration of diazepam (rectally or IV, 0.5 mg/kg; CRI, 0.5–1.5 mg/kg/h) or midazolam (rectally or IV, 0.5 mg/kg; CRI, 0.3 mg/kg/h) may be administered.
- If available, a CRI of glucagon may be administered at a rate of 15 ng/kg/min (6.8 ng/lb/min).¹¹
- Serial monitoring (ie, every 4–8 hours) of glucose concentration with a hexokinase method.

After management of hypoglycemic crisis and stabilization of the ferret, ultrasound of the pancreas assists in the identification of neoplasia (**Fig. 6**). Surgery, especially when partial pancreatectomy is performed, has a good prognosis (**Fig. 7**).⁶ However, recurrences do occur, and in such cases, medical treatment may palliate the symptoms.⁴ Medical treatment for long-term management of insulinomic ferrets may include corticosteroids, diazoxide, and octreotide, among other drugs.

Hypocalcemia

A less common cause of seizures in ferrets is severe hypocalcemia.¹² For the diagnosis, complete blood work, including ionized calcium, is indicated. Although no proper reference ranges for ionized calcium in ferrets are established, values higher than 1.1 mmol/L may be considered normal based on dogs' and cats' reference ranges (reference needed and unpublished data). Currently, there are point-of-care devices that evaluate ionized calcium along with the other electrolytes requiring only 0.2 mLs of whole blood (eg, CG8+ Cartridge, i-STAT, Abaxis, Darmstadt, Germany); however, their validity in ferrets has not been assessed. Differential diagnoses for hypocalcemia should include hypoparathyroidism, pseudohypoparathyroidism, hypomagnesemia, renal failure, acute pancreatitis, hypoalbuminemia, puerperal tetany, ethylene glycol intoxication, intestinal malabsorption, nutritional secondary hyperparathyroidism, and tumor lysis syndrome.^{12,13} Among these causes, primary hypoparathyroidism has been recently diagnosed in 2 ferrets and pseudohypoparathyroidism in another ferret.^{12–14} Diagnosis of these conditions is based on a combination of low-serum ionized calcium concentration, high-serum phosphorus concentration,

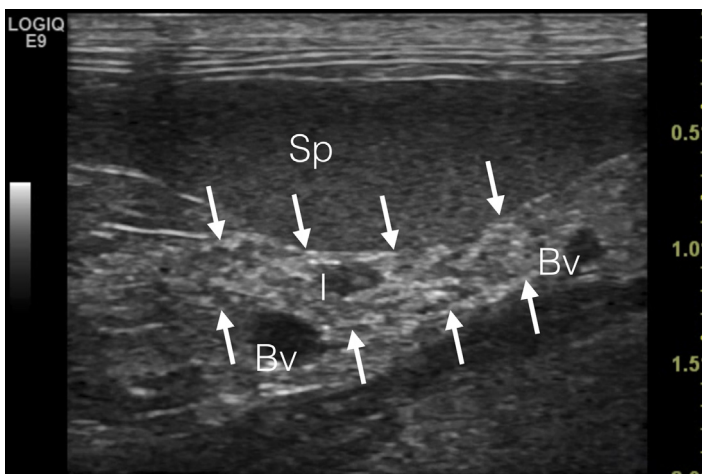


Fig. 6. Visualization of a hypoechoic mass in the left branch of the pancreas (*arrows*) of a ferret presented with hypoglycemic seizures, consistent with an insulinoma. Bv, blood vessel; I, insulinoma; Sp, spleen. (Courtesy of Annalisa Nicoletti, DMV, Rome, Italy.)

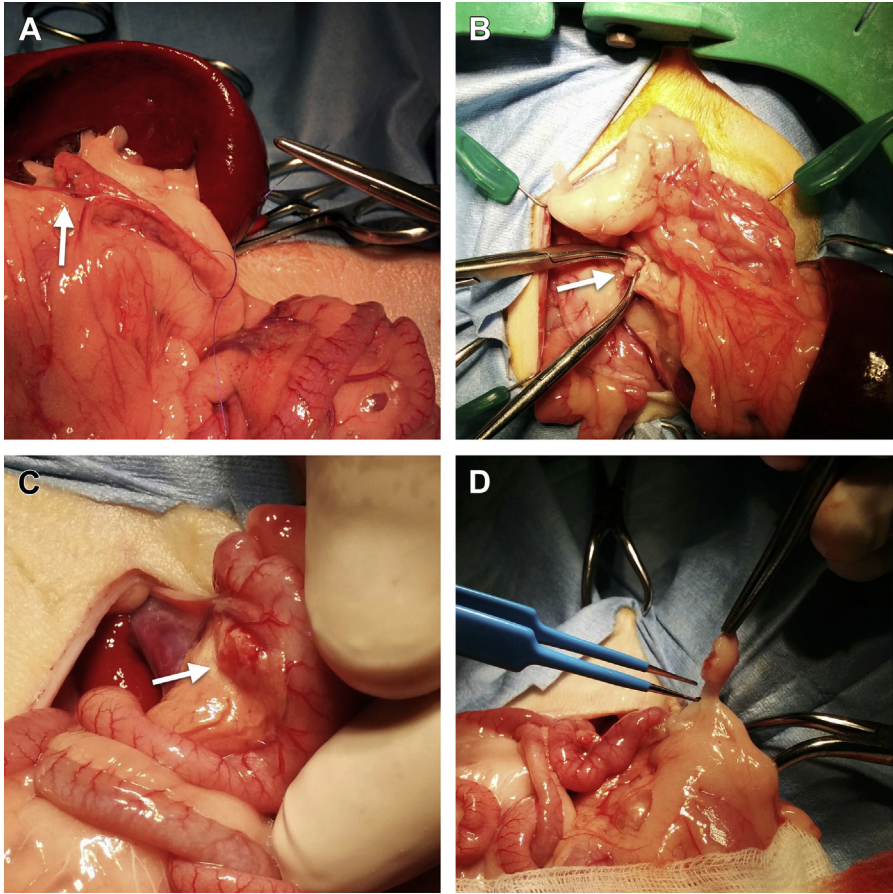


Fig. 7. Surgical treatment of insulinomas (arrows) in ferrets. In certain instances, removal of the neoplasm may be required to resolve the hypoglycemic crisis. Care needs to be paid to avoid the pancreatic duct. (A) Left pancreatectomy for multiple insulinomas on the left pancreatic limb. Given the free nature of the left limb, partial pancreatectomy is easily performed after placement of a monofilament ligature at the base of the limb. (B) Partial pancreatectomy for insulinoma on the body of the pancreas. The tissue enclosed in the 2 hemostatic forceps is removed. (C) Insulinoma on the right pancreatic limb. Notice the close relationship with the duodenum, which makes a radical pancreatectomy often unfeasible in these cases. (D) Nodulectomy of the previous insulinoma. This technique should be limited to insulinomas that cannot be removed with surrounding pancreatic tissue. (Courtesy of Nicola Di Girolamo, Rome, Italy.)

and appropriate renal function (based on serum chemistry values of serum urea nitrogen and creatinine) in the face of low parathyroid hormone (PTH) concentrations (hypoparathyroidism)¹² or high PTH concentrations (pseudohypoparathyroidism).¹⁴

Emergency treatment of hypocalcemic seizures is managed by CRI administration of calcium gluconate at 2 to 3 mg/kg/h, with continuous ECG monitoring controlling for bradycardia, ventricular premature complexes/contractions, or shortening of the QT interval (Fig. 8).^{12,13} In case of spontaneous primary hypoparathyroidism, long-term maintenance therapy with dihydrotachysterol (orally, 12–20 µg/kg/d) and calcium monitoring is indicated to control clinical signs.^{12,13}



Fig. 8. Emergency treatment of hypocalcemic seizures managed by administration of calcium gluconate (2–3 mg/kg/h) with ECG monitoring. (Courtesy of Nicola Di Girolamo, Rome, Italy.)

Other Causes of Seizures

Other disorders that occasionally cause central neurologic signs and seizures in ferrets include brain tumors, intoxication, and infectious diseases (viral, fungal, and protozoan infections), including distemper, rabies, Aleutian disease, systemic coronavirus, *Cryptococcus*, and *Toxoplasma gondii* infection (**Fig. 9**).^{2,15–18}



Fig. 9. Hyperkeratosis of the muzzle and foot pad (*inset*) during distemper infection in ferrets. Other presenting complaints include naso-ocular discharge, respiratory distress, and neurologic signs. (Courtesy of Nicola Di Girolamo, Rome, Italy.)

ANEMIA

Anemia in ferrets should be worked up as in other domestic animals. A preliminary diagnosis of anemia is formulated based on clinical features (Fig. 10) and hematology (hematocrit <45%). Most causes of anemia in other animals also occur in ferrets, including immune-mediated forms.¹⁹ Typical causes of anemia in ferrets are lymphoma and hyperestrogenism.

Hyperestrogenism-Related Anemia

Hyperestrogenism may be secondary to prolonged estrus in female ferrets (either intact or neutered with ovarian remnant), adrenal disorders, or, rarely, estrogen-producing tumors (Fig. 11).^{20–24} The mechanism behind anemia in intact female ferrets is from the lack of spontaneous ovulation. In the absence of copulation, ovulation does not occur, and the maintained production of estrogens by the follicles may result in bone marrow aplasia, with consequent pancytopenia.^{20,21}

Clinical signs of hyperestrogenism in female ferrets include swelling of the vulva, alopecia, and pruritus, among others (Fig. 12). In male ferrets, gynecomastia and dysuria as a consequence of prostatic cysts are occasionally observed during hyperestrogenism.

Emergency treatment includes (1) stabilization of the ferret and (2) removal of the source of endogenous estrogen production.²⁵

Transfusions

Transfusions are anecdotally indicated for hematocrit values lower than 25%.²⁶ Ferrets do not have clinically significant blood groups²⁷; therefore, any healthy adult male ferret is an appropriate donor. As a clinical guide, avoid sampling more than 1% of the ferret body weight (ie, in a 1.5-kg ferret, 15 mL of blood). Some investigators suggest drawing blood with cardiac puncture to permit a rapid, clot-free collection.²⁷ However, in the author's clinical experience, transfusion is safely performed even with blood samples obtained from the cranial vena cava with a 23-G needle and use of a 170- μ m clot filter (Fig. 13). Rate of administration of blood for the recipient depends on the underlying disorder (ie, acute vs chronic loss) and ranges from 20 minutes to a maximum of 4 hours.²⁸ Ferret blood stored using citrate-phosphate-dextrose-adenine should not be used for transfusion after 7 days of storage at 4°C.²⁹

Removal of estrogen source

Hyperestrogenism from persistent-estrus Currently, gonadectomy in ferrets is discouraged given the consequent increase in risk of developing adrenal disease.³⁰

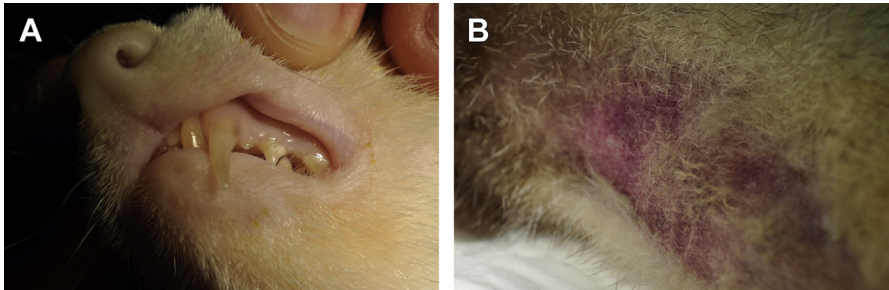


Fig. 10. Pallor of the oral mucous membrane (A) and subdermal hemorrhagic effusion (B) in a ferret with anemia and thrombocytopenia. (Courtesy of Nicola Di Girolamo, Rome, Italy.)

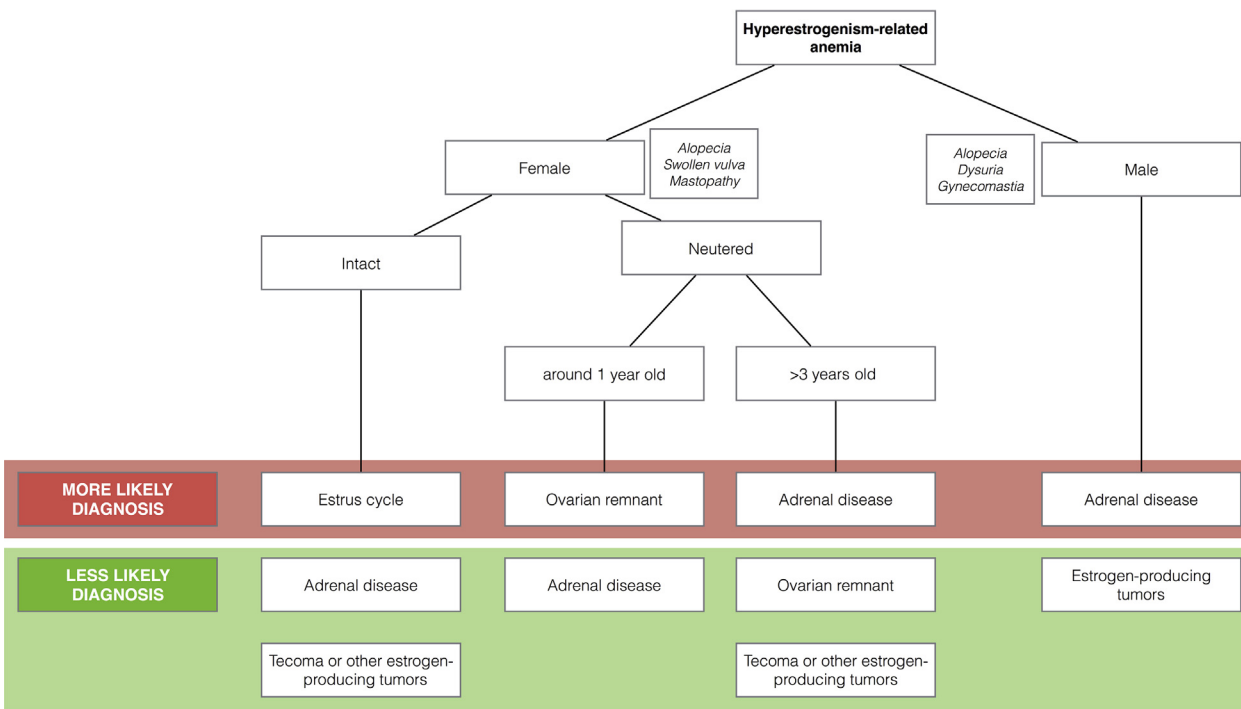


Fig. 11. Suggested differential diagnoses to consider during hyperestrogenism-related anemia.



Fig. 12. Clinical signs of hyperestrogenism, swollen vulva (A), and alopecia (B). (Courtesy of Nicola Di Girolamo, Rome, Italy.)

Therefore, alternative medical treatments should be elected. In ferrets, ovulation may be induced with the following^{26,31,32}:

- Human chorionic gonadotropin (100 IU)
- Medroxyprogesterone (15 mg)
- Proligestone (40 mg)
- Gonadotropin-releasing hormone (GnRH; 20 µg/kg)
- Long-term depot GnRH agonists (4.7 mg deslorelin acetate [Suprelorin, Virbac])

Hyperestrogenism from adrenal hyperplasia or neoplasia Current therapies for adrenal disease in ferrets include medical and/or surgical treatment. The GnRH agonist, deslorelin acetate, 4.7-mg dose proved to be an interesting alternative to surgical adrenalectomy.³³ However, in ferrets that do not respond to medical treatment (ie, persistence of symptoms, evidence of increase in size of the adrenal gland³⁴) (Fig. 14), surgery is indicated (Fig. 15). Percutaneous ultrasound-guided alcoholization of the adrenal gland may be a palliative alternative (Fig. 16).

Hyperestrogenism from estrogen-producing tumors The treatment of choice depends on type of tumor, location, and so on. Ideally, as soon as the ferret is stabilized, prompt surgical removal is indicated to discontinue estrogen production.²⁴

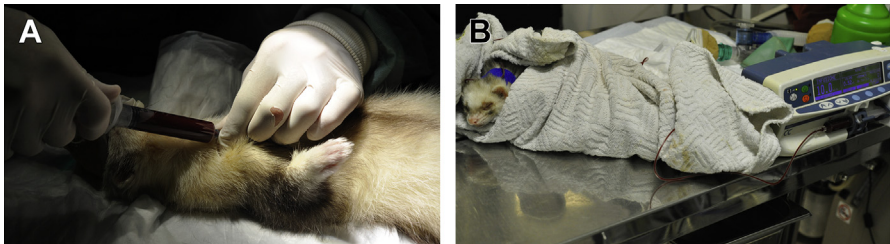


Fig. 13. Transfusions in ferrets are empirically indicated for hematocrit values lower than 25%. Any healthy adult male ferret is an appropriate donor because ferrets do not have clinically significant blood. In the author's clinical experience, transfusion is safely performed even with blood samples obtained from the cranial vena cava with a 23-G needle (A). Blood is then perfused in the receiver (B).

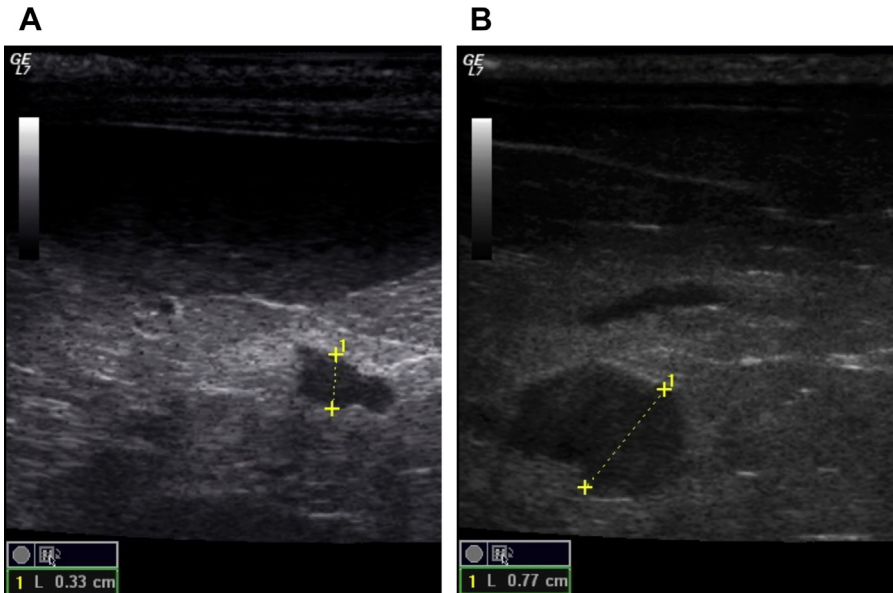


Fig. 14. Echographic visualization of normal (A) and increased left adrenal gland (B) (normal thickness <3.9 mm). (Courtesy of Annalisa Nicoletti, DMV, Rome, Italy.)

INTOXICATION

Because of their curious nature and strong jaws that allow them to open pill vials and sealed containers, ferrets are prone to toxin exposure. Because of their small size, even small ingestions of a toxicant can lead to a large exposure on a milligram per kilogram basis.³⁵ Furthermore, intoxication in ferrets may occur as a consequence of inherited defects, as in the case of copper toxicosis.³⁶ The treatment of toxicity in ferrets should be approached the same as in any other species.³⁵ General treatments should be started and, when available, specific therapy for a toxicant should be instituted. If there is substantial evidence of recent intoxication (ie, within 2 hours), when indicated, emesis can be achieved with oral administration

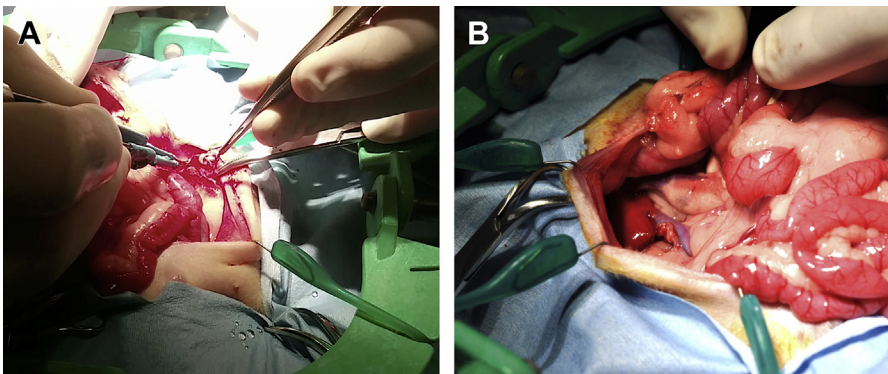


Fig. 15. Left (A) and right (B) adrenalectomies in ferrets. Currently, the use of 4.7-mg deslorelin acetate depot is a medical alternative to surgery, which remains required in certain cases. (Courtesy of Nicola Di Girolamo, Rome, Italy.)

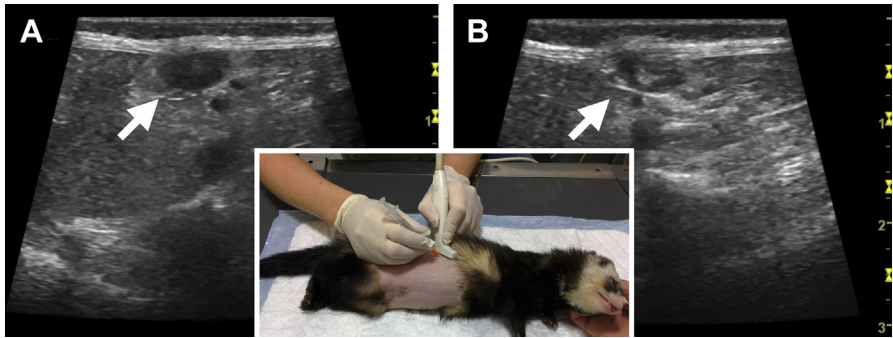


Fig. 16. Ultrasound-assisted alcoholization of an enlarged adrenal gland (*arrow*) in a ferret. (A) Adrenal gland before the procedure. (B) Adrenal gland after percutaneous injection of 0.05 mL of 95% ethanol with a 25-G needle. (*Courtesy of Annalisa Nicoletti, DMV, Rome, Italy*)

of 3% hydrogen peroxide (0.45 mL/kg), syrup of ipecac (0.25–1 mL/kg, orally), or apomorphine (0.04 mg/kg, IV, subcutaneously, or intramuscularly [IM]).^{35,37} Emesis should not be induced for ingestion of corrosives such as alkalis, acids, cationic detergents, and petroleum distillates.³⁵ Finally, if the animal is already symptomatic (eg, vomiting, depressed, seizing), induction of emesis is not indicated.³⁷

Ibuprofen Toxicosis

A single tablet of common size ibuprofen (200 mg) could be fatal to an average-sized ferret.

Common presenting complaints include the following³⁸

- Neurologic signs (93.1% of ferrets with presumed toxicosis): depression, coma, ataxia, recumbency, tremors, and weakness
- Gastrointestinal (GI) signs (55.2%): anorexia, vomiting, retching or gagging, diarrhea, and melena
- Renal signs: polydipsia, polyuria, dysuria, renal failure
- Other findings: shallow breathing, metabolic acidosis, dehydration, and hypothermia.

Treatment for ibuprofen toxicosis in the ferret includes stabilization, GI decontamination, fluid diuresis, GI protection, and supportive care. The ingestion of ibuprofen has an unfavorable prognosis unless the animal is decontaminated early and given aggressive treatment. However, in a retrospective study of suspect ibuprofen toxicosis, death was reported in only 14% of cases (4/29 cases).³⁸

Anticoagulant Rodenticide

Anticoagulant rodenticides interfere with the liver's production of clotting factors II, VII, IX, and X. Signs of hemorrhage are not evident right after intoxication, typically taking 1 to 3 days after ingestion to occur. Hemorrhages may occur anywhere, including thorax, abdomen, subcutis, and central nervous system (**Fig. 17**).³⁹ Emergency treatment should be aimed at stopping hemorrhage, correcting anemia, and supplementing vitamin K1. Although there is a lack of clinical research data on ferrets, vitamin K1 is empirically indicated at a dose of 5 mg/kg divided every 8 to 12 hours.³⁵ Oral vitamin K1 should be given with a fatty meal because bile acids are needed for its absorption, while injections are generally discouraged for the risk of anaphylactic reactions.³⁹ Plasma or whole blood may be given in symptomatic ferrets to provide clotting factors.



Fig. 17. Post-mortem of a ferret with hemothorax after anticoagulant intoxication.

In case of anemia, whole blood transfusions are indicated. Course of treatment depends on the rodenticide (around 2–4 weeks) during which coagulation parameters should be monitored ([Table 1](#)).^{35,40}

ACUTE ABDOMEN

Ferrets presented with an acute onset of abdominal pain should be closely evaluated, because the underlying cause of acute abdomen in the ferret may be minor and transient

Coagulation Parameter	Mean	Range
PT (s)	10.9	(10.6–11.6)
PTT	20.0	(18.6–22.1)
PTT + ellagic acid	18.1	(16.5–20.5)
Fibrinogen	107.4	(90.0–163.5)
Antithrombin (%)	96	(69.3–115.3)

Abbreviations: PT, prothrombin time; PTT, partial thromboplastin time.

Adapted from Benson KG, Paul-Murphy J, Hart AP, et al. Coagulation values in normal ferrets (*Mustela putorius furo*) using selected methods and reagents. *Vet Clin Pathol* 2008;37:288.

or an immediately life-threatening process. Acute abdomen may result from specific injury or disease of the peritoneal or retroperitoneal structures, diaphragm, or body wall constituents,¹ with pain from the spine also frequently referred as abdominal pain.

Gastrointestinal Obstruction

GI foreign bodies are particularly common in ferrets, especially in young individuals.⁴¹ Ferrets seem to be attracted to plastic and latex objects. Vomiting and/or diarrhea are frequent presenting complaints. Occasionally, gastric dilatation-volvulus may occur.⁴² Radiography and ultrasonography are usually sufficient for diagnosis (Fig. 18A), although in some instances, other diagnostic techniques are required (Fig. 18B). Obstructing intestinal foreign bodies should be considered a surgical emergency, and exploratory laparotomy should be performed as soon as the ferret is able to withstand general anesthesia (Fig. 19).

Intestinal Perforation

Intestinal perforation may occur as a consequence of GI foreign bodies or neoplasia of the intestinal tract and should be considered a surgical emergency. Treatment

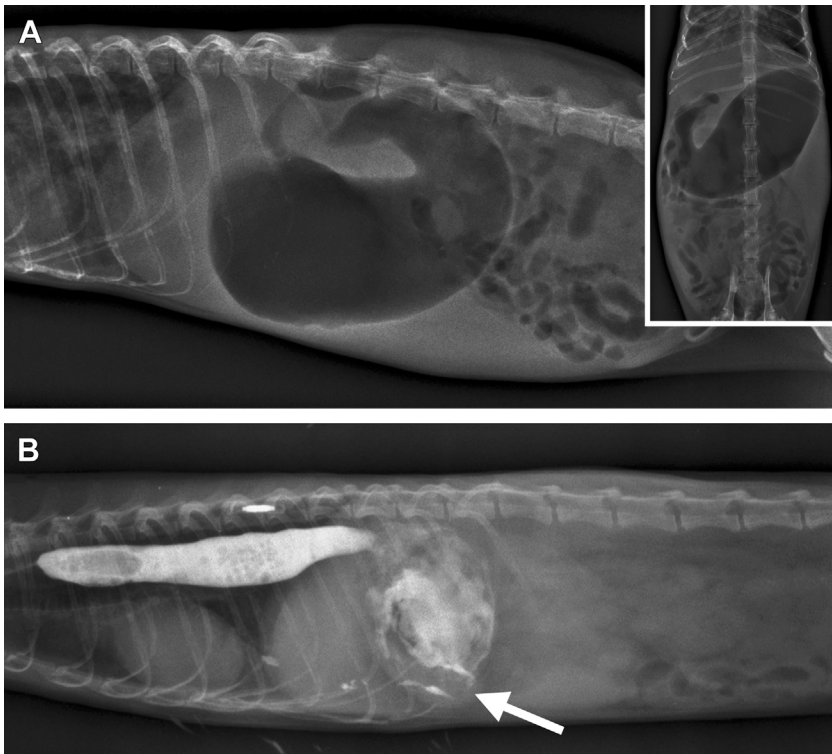


Fig. 18. Radiographic findings in ferrets with GI foreign bodies. (A) Lateral radiograph of a gas-dilated stomach. Inset: ventrodorsal view. (B) Ferret presented with regurgitation; ultrasound was not diagnostic. Contrast radiograph shows a filling defect in the stomach (arrow) consistent with a large foreign body (trichobezoar). Notice the subsequent dilated esophagus, which should not be confused with an idiopathic megaesophagus. Barium should be never administered in cases of possible GI perforation. (Courtesy of Nicola Di Girolamo, Rome, Italy.)

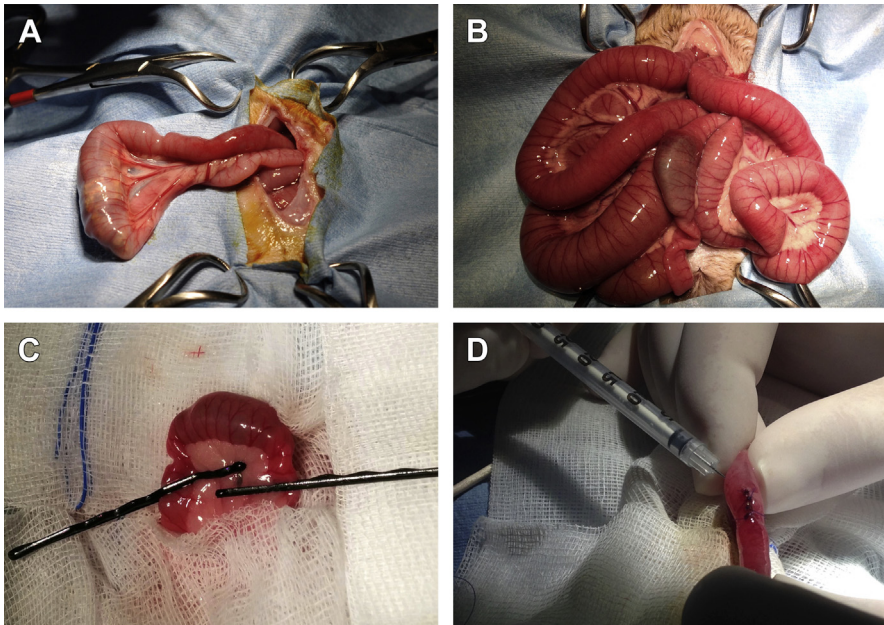


Fig. 19. Urgency of enterotomy for foreign body removal depends on several factors. (A) Enterotomy in a ferret presented for anorexia. (B) Enterotomy in a ferret that was forced for 2 days by the referring veterinarian. Notice extreme dilation of the intestinal tract before the obstruction. These cases should be considered surgical emergencies. (C) Use of hair clip to avoid surgical field contamination. (D) Injection of saline by use of a 0.3-mL syringe with a 31-G needle to assess absence of leaking from the enterotomy site. (Courtesy of Nicola Di Girolamo, Rome, Italy.)

consists of stabilization of the patient and resection of the affected tract of the intestine (Fig. 20). In cases of perforating foreign bodies, excision of a small area of intestine around the perforation (after foreign body removal) may be a valid alternative to end-to-end anastomosis. In the author's experience, the prognosis is generally guarded.

Biliary Disorders

Biliary disorders are increasingly being diagnosed in ferrets.^{43,44} Ferrets with biliary disorders may present with discolored (acholic) feces (Fig. 21), icteric mucus membranes, vomiting, anorexia, and lethargy. Alanine aminotransferase (ALT) and total bilirubin are usually elevated (reference ranges, ALT: 70–100 U/L; total bilirubin: 0.2–0.5).⁴⁵ Ultrasonography of the gallbladder may identify surgical emergencies (ie, obstruction and rupture; Fig. 22A).

- Cholelithiasis and obstruction
 - Usually requires immediate surgical treatment, with removal of the cholelith (Fig. 22B).⁴³
- Cholecystitis
 - Depending on the severity of the disorder, it may be appropriate to attempt medical treatment, such as antibiotics, gastroprotectants, and ursodeoxycholic acid (Fig. 23A, B). In severe cases, cholecystectomy is indicated (Fig. 23C).

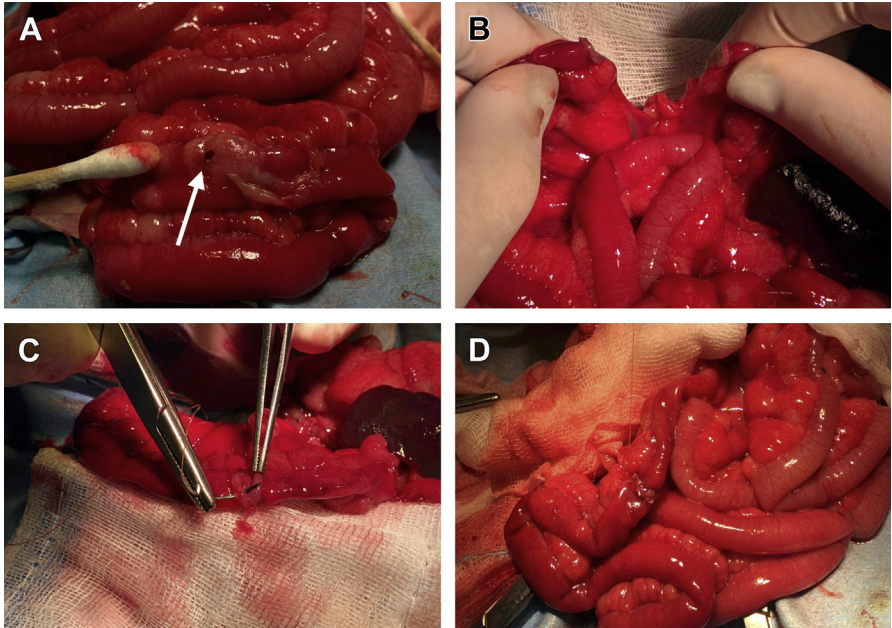


Fig. 20. Emergency enterectomy in a ferret with intestinal perforation. (A) Intestinal perforation (*arrow*). Notice the altered surrounding tissue and peritonitis. (B) Enterectomy. (C, D) Anastomosis of the 2 cut ends in a simple interrupted pattern with monofilament absorbable suture. (Courtesy of Nicola Di Girolamo, Rome, Italy.)

- Rupture of the gallbladder
 - Requires immediate surgical treatment, consisting of cholecystectomy and peritoneal lavage (**Fig. 24**).⁴⁴

Spleen Disorders

Conditions requiring immediate surgical treatment include splenic torsion and rupture. Both are quite uncommon in ferrets.⁴² Splenomegaly is a more common condition but usually does not require emergency treatment. However, in some cases, generalized



Fig. 21. Acholic feces in a ferret with ruptured gallbladder. (Courtesy of Nicola Di Girolamo, Rome, Italy.)

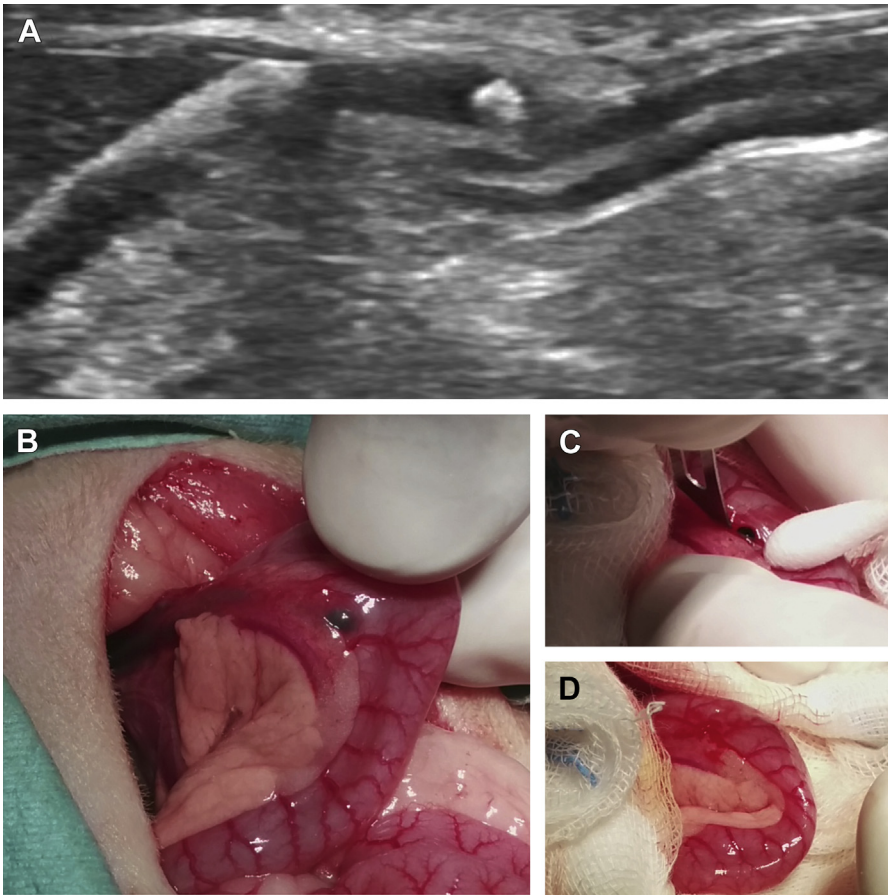


Fig. 22. Cholelithiasis in ferrets may be a surgical emergency. (A) Ultrasonographic visualization of a cholelith in the common bile duct. Notice the dilation of the duct. (B–D) Surgical removal of the cholelith from the common bile duct. (Courtesy of Nicola Di Girolamo, Rome, Italy.)

splenomegaly (hypersplenism) or large splenic masses may result in weakness, lethargy, anorexia, and even vomiting from mechanical compression of the stomach (Fig. 25A). In these cases, splenectomy may resolve the symptoms (Fig. 25B).^{46,47} Histology should always be performed on the removed spleen for diagnosis of subtle lymphomas.

Intervertebral Disk Prolapse

Intervertebral disk prolapse in ferrets generally occurs at the level of the lumbar vertebrae and results in ambulatory deficits of the hind limbs (Video 4).^{48,49} Vertebral trauma can lead to a similar clinical presentation. Such alteration should not be confused with the common hind limb weakness that affects ferrets in a variety of conditions, including hypoglycemia and congestive heart failure (CHF), or with paresis related to neuromuscular disease, as in a course of myasthenia gravis or disseminated idiopathic myositis.^{50,51} A preliminary indication during emergency consultation may be provided by radiographs of the lumbar vertebrae. Definitive diagnosis requires

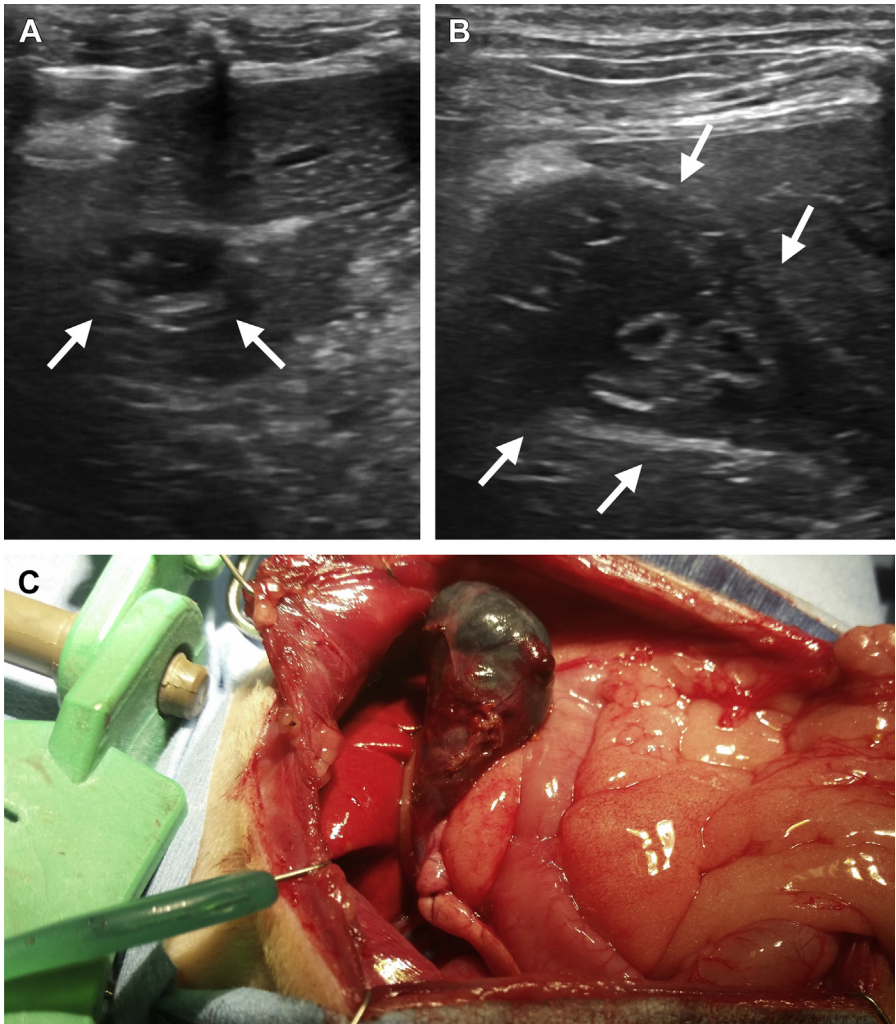


Fig. 23. Ferret with cholecystitis should be carefully monitored, and removal of the gallbladder should be performed if required. (A) Gallbladder presenting a thickened wall but normal content (arrows). The ferret was successfully managed medically. (B) Necrotizing cholecystitis in a ferret. Notice thickened wall and structured content of the gallbladder (arrows). (C) Surgical removal of the gallbladder in (B). After blunt isolation of the gallbladder, the cystic duct is ligated and the gallbladder excised. (Courtesy of Nicola Di Girolamo, Rome, Italy.)

myelography, computed tomography (CT), or MRI, although the latter 2 techniques are preferred. Treatment options include hemilaminectomy and/or conservative physiotherapy, hydrotherapy, and low-level laser therapy.^{48,49,52}

ACUTE KIDNEY INJURY

In ferrets, acute kidney injury (AKI) (acute renal failure) may result from prostatic disease, urolithiasis, ureteral obstruction (stenotic and retrocaval ureters), toxic exposure, and infectious disease (Fig. 26).^{38,53–55}

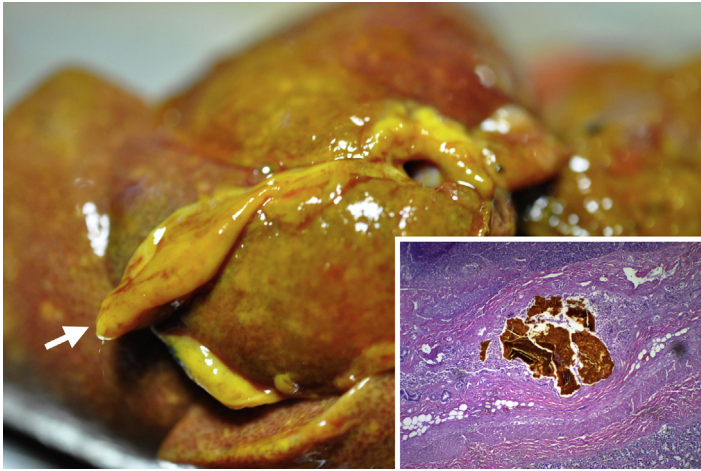


Fig. 24. Post-mortem appearance of a ruptured gallbladder (*arrow*) in a ferret resulting in bile peritonitis. Inset: presence of bile plug within bile duct. (Courtesy of Raffaele Melidone, Boston, MA.)

Initial laboratory evaluation should include a complete blood count, serum biochemistry profile, assessment of acid-base status, urinalysis, and urine culture. Hyperkalemia occurs primarily in oliguric or anuric ferrets. Radiography and ultrasonography may serve as a diagnostic imaging step to aid in the assessment of a ferret with suspected AKI (**Fig. 27**). CT and excretory urography may be required to characterize

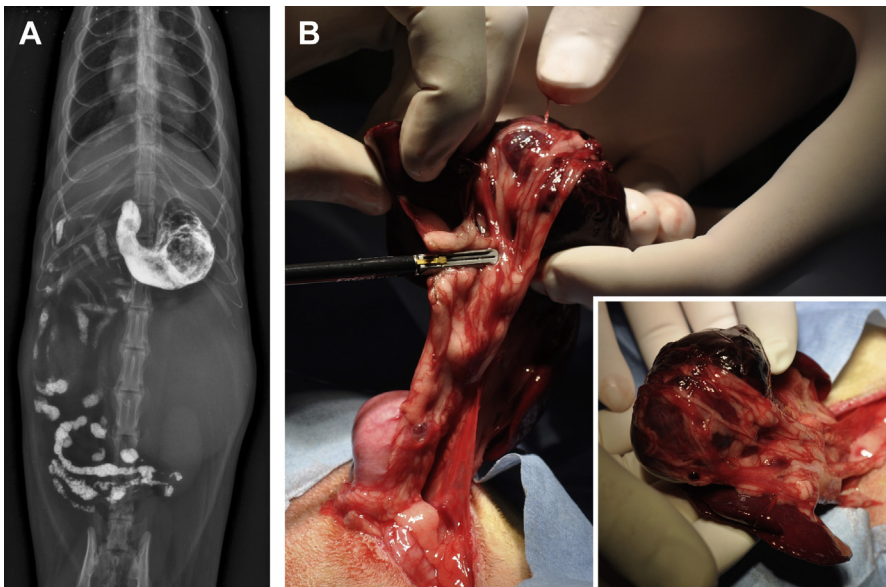


Fig. 25. Ferret presented for several vomit episodes per day despite a normal endoscopic aspect of the stomach. (A) Contrast radiography shows the compression caused by a splenic mass in the GI tract. (B) Removal of the spleen by use of a tissue-sealing device (Enseal, Ethicon). Inset: Notice the large splenic mass. (Courtesy of Nicola Di Girolamo, Rome, Italy.)



Fig. 26. Dermatologic lesions in ferrets with kidney failure. (A) Skin ulcers presumed to be secondary to uremia in a ferret with kidney failure. (B) Edema of the extremities in a ferret with nephrotic syndrome. (Courtesy of Nicola Di Girolamo, Rome, Italy.)

some disorders (Fig. 28), for example, focal dilation of the ureters (Fig. 29). The primary treatment should be aimed at the underlying cause of AKI (eg, ureteral bypass, antidotes for toxins); however, correction and maintenance of the animal's hydration, acid-base, and electrolyte status are the mainstays of management for AKI.

Urethral Obstruction

Urethral obstruction is a condition that requires immediate care and may be secondary to prostate enlargement (frequently secondary to adrenal disease), urethrolithiasis, and urethral masses. In male ferrets, even small uroliths may cause a life-threatening post-renal obstruction because of the narrow diameter of the urethra and the os penis. The

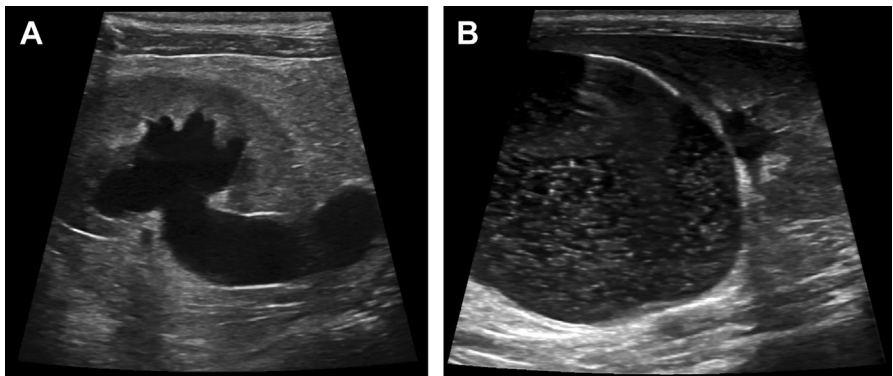


Fig. 27. Common ultrasonographic findings in ferrets with kidney failure. (A) Segmental ureteral dilation and hydronephrosis. (B) Large cyst in the renal parenchyma.

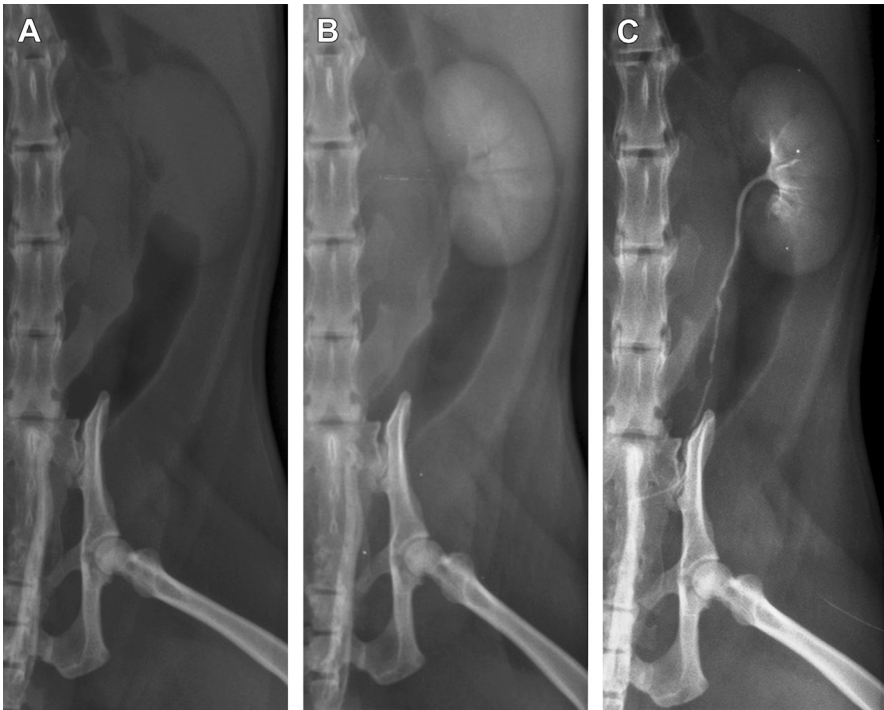


Fig. 28. Different phases of left renal enhancement during excretory urography in a ferret. (A) Plain radiograph, before administration of IV contrast medium. (B) Nephrographic phase. The nephrographic opacity should decrease progressively with time after injection. (C) Pyelographic phase. The width of pelvic recesses, renal pelvis, and proximal ureter may be measured in this phase. (Courtesy of Nicola Di Girolamo, Rome, Italy.)

urethrolith may be dislodged by means of urethral catheterization and retrograde urohydropulsion to the bladder (Fig. 30). If retrograde urohydropulsion is unsuccessful, perineal urethrostomy or temporary tube cystostomy permits urine voidance (Fig. 31). Temporary tube cystostomy may be performed as follows⁵⁶:

- During laparotomy, a cystostomy tube (5- or 8-French Foley catheter) is passed in a paramedian incision in the ventral body wall.
- A Foley catheter is passed into the urinary bladder, inflated, and fixated with a purse-string suture.
- The bladder is tacked to the body wall with simple interrupted sutures.
- The abdomen is closed routinely, and the skin around the exiting Foley catheter is closed with a purse-string suture. A finger-trap connected to the purse-string suture is placed around the Foley catheter.

DIABETIC KETOACIDOSIS

Diabetic ketoacidosis is a severe, life-threatening complication of diabetes mellitus, characterized by the biochemical triad of hyperglycemia, acidosis, and ketosis. As compared with dogs and cats, ferrets rarely suffer diabetes mellitus. Diabetes

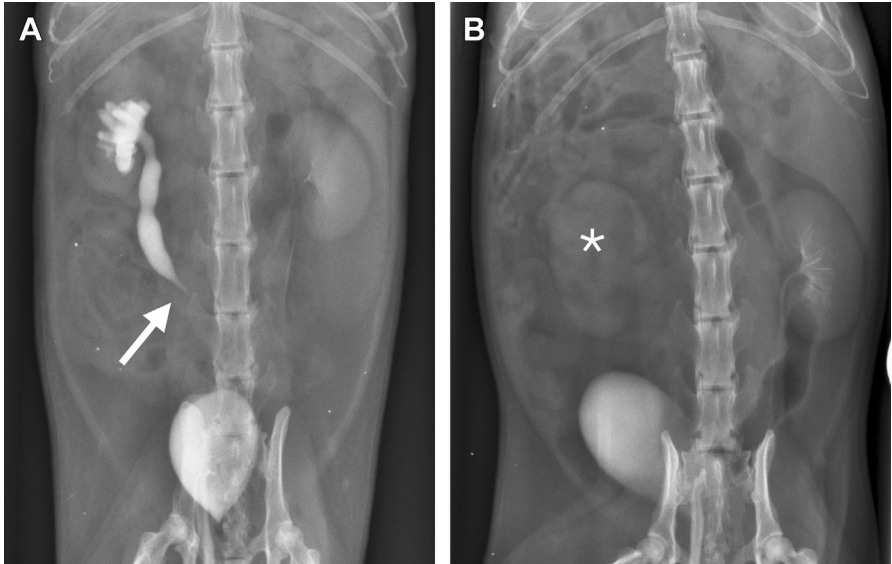


Fig. 29. Visualization of disorders during altered excretory urography in ferrets. (A) Presence of a segmental ureteral stenosis (*arrow*) and subsequent hydronephrosis of the right kidney. (B) Lack of contrast enhancement of the right kidney (*asterisk*). (Courtesy of Nicola Di Girolamo, Rome, Italy.)

mellitus in ferrets may be spontaneous, iatrogenic, or as a postoperative sequela to pancreatectomy.⁵⁷⁻⁵⁹ Treatment of diabetes ketoacidosis consists of fluid therapy, electrolyte corrections, and insulin therapy.^{57,59} Previous experience suggests using initially short-acting insulin to gain glycemic control (0.25 U/kg, IM, every 4 hours),⁵⁷

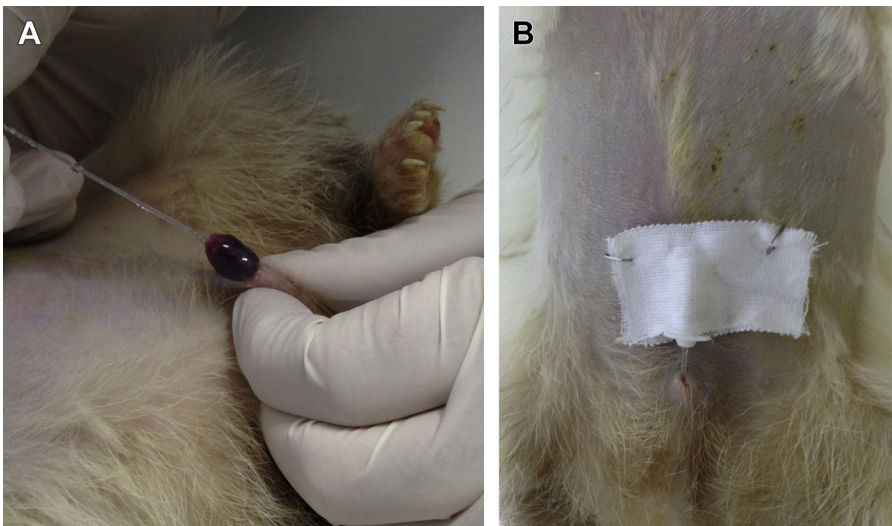


Fig. 30. Urethral catheterization in a male ferret (A). Notice fixation of the catheter to the skin (B). (Courtesy of Daniele Petrini, Pisa, Italy.)

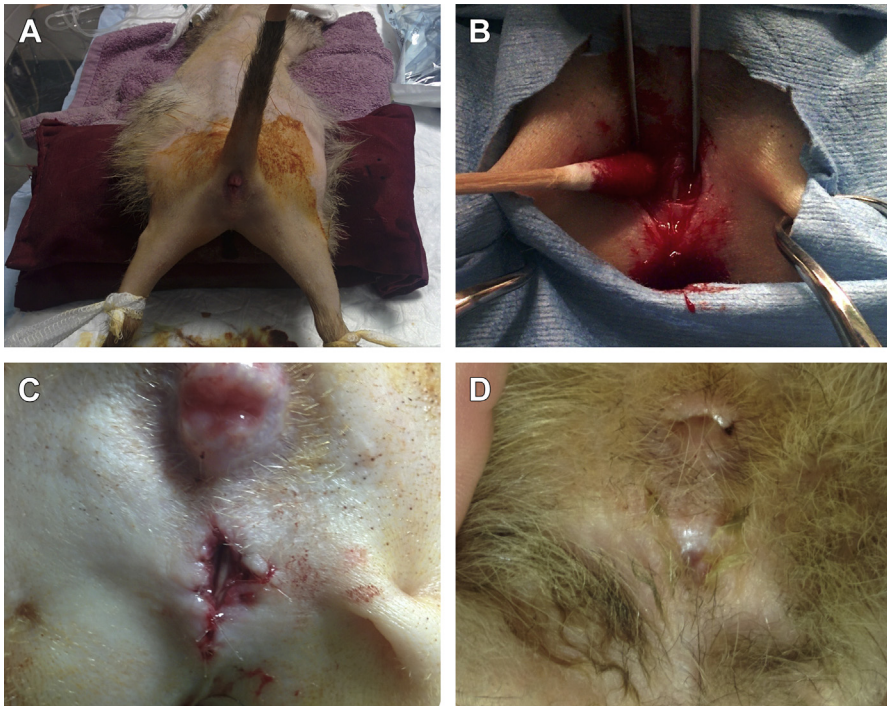


Fig. 31. Perineal urethrostomy in a male ferret. (A) Preparation of the ferret on the surgical table. (B) Incision of the skin, retraction of the perineal muscles, and exposure of the urethra. The localization of the urethra is favored by the previous positioning of a urinary catheter. (C) Placement of monofilament sutures from the urethral wall to the perineal skin. (D) Appearance of the surgical site 6 months after treatment. (Courtesy of Nicola Di Girolamo, Rome, Italy.)

after which switching to long-acting insulin (insulin glargine) for maintenance glycemic control (0.5 U, subcutaneously, every 12 hours).⁵⁸

CONGESTIVE HEART FAILURE

Cardiac disease in ferrets is far more common than previously thought,⁶⁰ and CHF is a common emergency condition in ferrets requiring immediate care. Ferrets with CHF may present to the emergency department with cough, respiratory distress, syncope, ascites, and/or generalized or hind limb weakness. The ferret may acquire an orthopedic position while breathing (Fig. 32). After evaluation of heart rate, rhythm, murmurs, pulse, capillary refill time, and thoracic percussion for fluid presence, radiographs should be obtained. Assessment of the vertebral heart scale (VHS) is a rapid, but limited technique that may assist the nonexpert radiologist in evaluating the cardiac silhouette (right lateral VHS reference interval: 5.2–5.5 vertebrae; Fig. 33).⁶¹ Thoracic ultrasonography and ECG are typically needed to make a definitive diagnosis.

Depending on the cause of CHF, different emergency treatments should be planned:

- Oxygen, provided both via flow-by (4–6 L/min) and in an oxygen cage, should be administered to hypoxic ferrets.



Fig. 32. Orthopneic position in a ferret with CHF. This position is also observed in healthy ferrets and should not be considered diagnostic.

- Suspected pulmonary edema is empirically treated with an initial IM administration of furosemide at 4 mg/kg, followed by recheck radiographs at 3 to 5 hours, and decreased to 2 or 1 mg/kg, once or twice a day (**Fig. 34**).
- In ferrets presenting with significant pleural effusion (**Fig. 35**), thoracentesis should be performed immediately for diagnostic and therapeutic purposes (**Fig. 36**; **Video 5**). Effusion of cardiac origin should be differentiated from chylothorax and pyothorax (eg, *Pseudomonas luteola* and *Nocardia* sp infection).^{62,63} Chylous effusion may have a “milky” appearance (**Fig. 37**) or may be transparent;

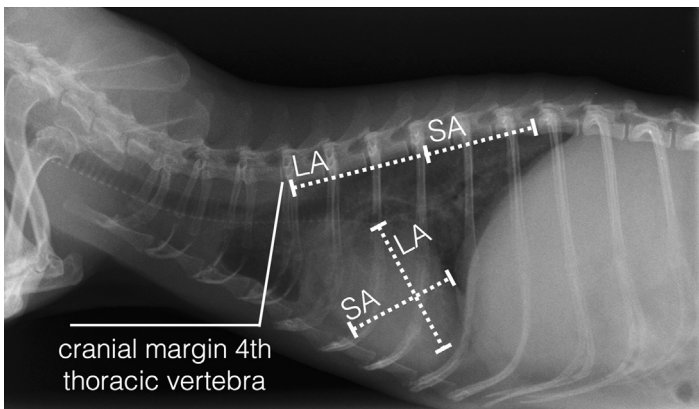


Fig. 33. Radiographic measurement of the VHS in a cardiopathic ferret (6 vertebrae, reference interval: 5.2–5.5). The long axis (LA) is the length of the heart from ventral border of bifurcation of the mainstem bronchi to the apex. The short axis (SA) is the maximal width of the heart perpendicular to the long axis. The 2 measurements are placed on the cranial margin of the 4th thoracic vertebra, and the number of vertebrae are counted to the nearest 0.25 vertebra.

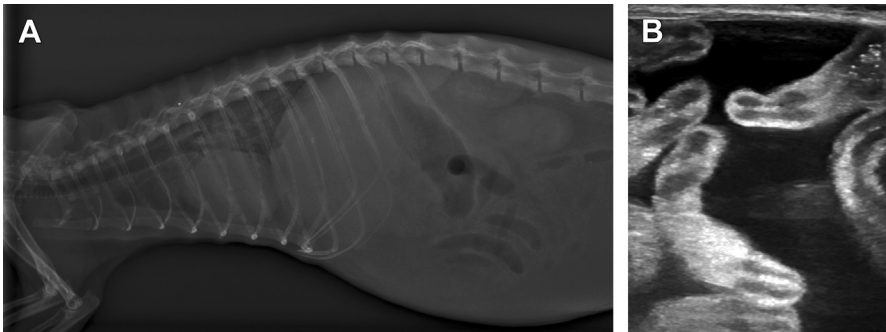


Fig. 34. Diagnostic imaging findings in a ferret with biventricular heart failure. Radiograph showing alveolar pattern (consistent with lung edema) and ascites (A). Abdominal ultrasound confirms ascites (B).

therefore, visual assessment may not be diagnostic.⁶⁴ A high effusion:serum triglyceride ratio (2–10:1) is suggestive of chylothorax.⁶⁵ In dubious cases, the presence of chylomicrons in the lipoprotein electrophoresis from the effusion is diagnostic.⁶⁴ Lymphangiography permits evaluation of the thoracic duct (see [Fig. 37](#)).

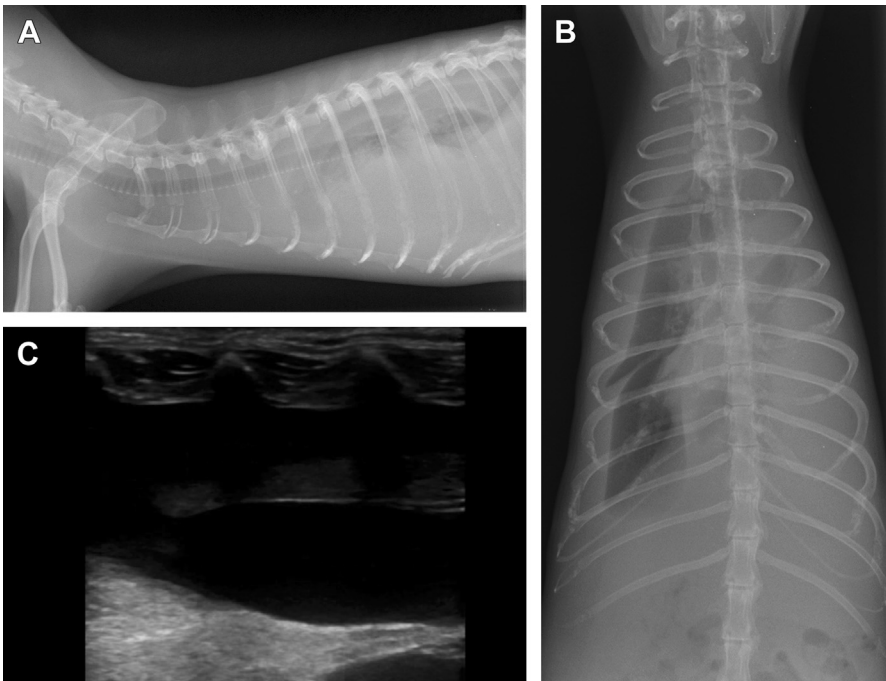


Fig. 35. Diagnostic imaging findings in a ferret with CHF and subsequent pleural effusion. Lateral (A) and ventrodorsal radiographs (B). Notice the silhouetting sign and pleural fissures. Ultrasonography assists in estimation of the quantity of fluid (C). (Courtesy of Nicola Di Girolamo, Rome, Italy.)

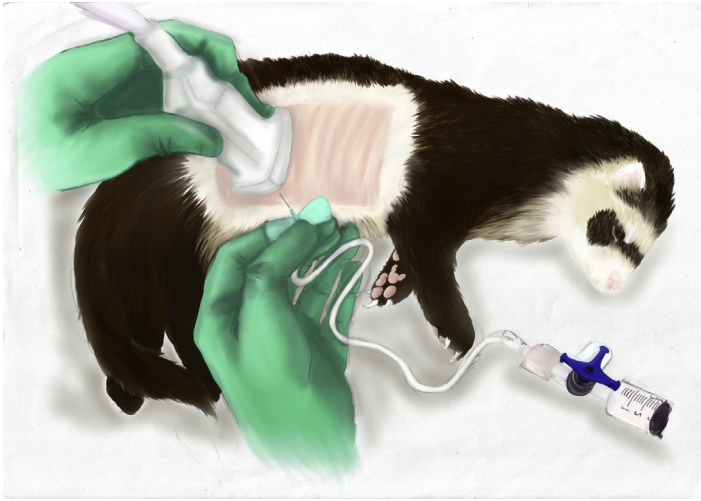


Fig. 36. Ultrasound-assisted thoracentesis is an emergency procedure that may be performed under slight sedation in the case of pleural effusion or pneumothorax. (Courtesy of Virginia Bua, Rome, Italy.)

Valvular Regurgitation and Cardiomyopathies

Valve incompetence is the most common cause of cardiac disease in ferrets.⁶⁰ Dilated, hypertrophic, and restrictive cardiomyopathies are less common, but often associated with CHF.⁶⁰ In the author's experience, the use of an electronic stethoscope may simplify auscultation of ferrets and usually permits the identification of murmurs (Fig. 38A). Valvular disorders are diagnosed by Doppler echocardiography and should be treated as in other small animals. Empirically, the author uses pimobendan (0.25–0.5 mg/kg, twice a day) and benazepril (0.5 mg/kg, once a day).⁶⁶ Chronic diuretic use of furosemide, at the lowest dose to control signs of CHF, is needed.

Atrioventricular Block

Atrioventricular block is common in ferrets, and third-degree atrioventricular block often results in CHF.⁶⁰ In most ferrets, ECG may be performed without need of chemical restraint. The ferret may be maintained in a vertical, “hanging” position (Fig. 38B),⁶⁷ or manually restrained in the lateral position. Administration of commercial malt paste may simplify restraint of uncooperative individuals. The ECG is interpreted as in other domestic animals (Fig. 39), and values of healthy individuals are detailed elsewhere.⁶⁷ Treatment options include medical therapy with sympathicomimetic medications (isoproterenol, metaproterenol) or cardiac pacing. Both epicardial and intracardial pacing have been successfully performed in ferrets.^{68,69}

Filariosis

Caval syndrome caused by adult heartworms may occur in ferrets living in areas endemic of the disease. Accuracy of SNAP ELISA (enzyme-linked immunosorbent assay) -based antigen tests is unclear in ferrets, and it is suspected those tests may give false negative results. Diagnosis is based on evidence of adult worms in the heart

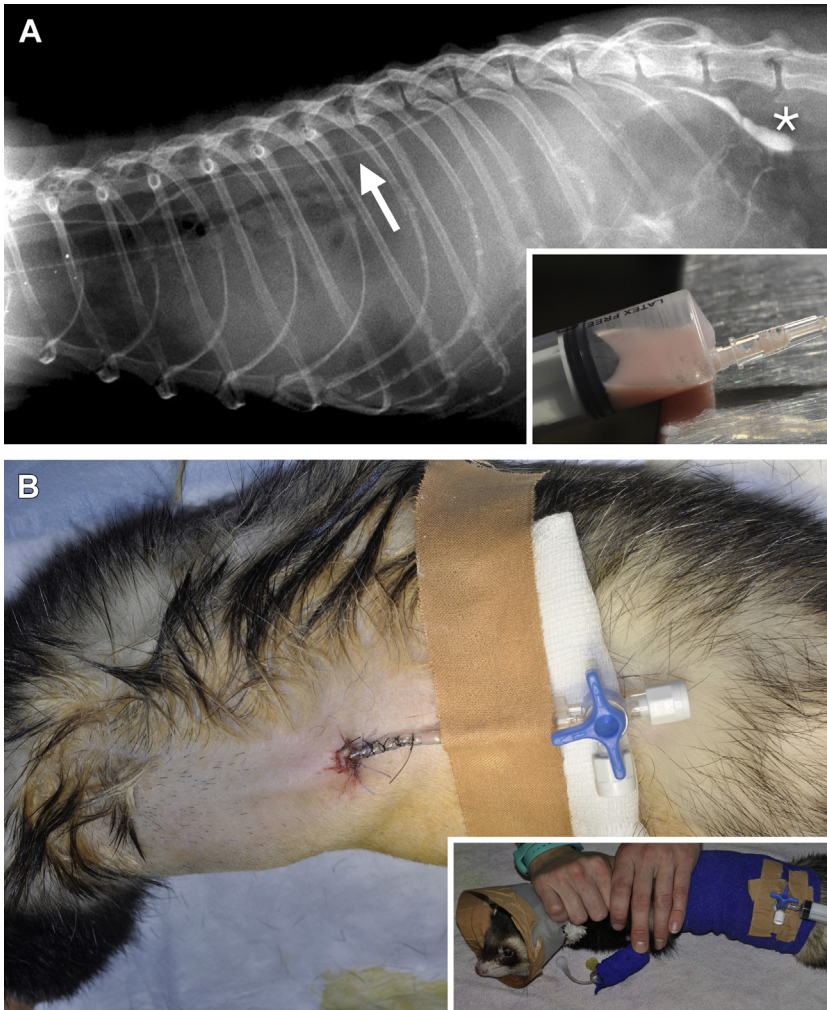


Fig. 37. Chylothorax should be differentiated from cardiogenic pleural effusion. (A) Lymphangiogram of the thoracic duct (*arrow*) in a ferret. Under ultrasonographic guidance, 60 mg/kg of iohexol contrast medium was injected in the mesenteric lymph nodes. Notice the cisterna chyli (*asterisk*). Inset: typical aspect of chylous. However, transparent chylous effusion is not uncommon. (B) Thoracic drainage may be placed in cases of severe, recurring chylous effusion. (Courtesy of Nicola Di Girolamo, Rome, Italy.)

and cranial vena cava by ultrasonography. In a ferret, heartworms had been transvenously extracted.⁷⁰

- The jugular vein is dissected; a basket endoscopic retrieval device is inserted into the vein and advanced into the cranial vena cava with fluoroscopic guidance, and heartworms are extracted.

Medical adulticide therapy using melarsomine in ferrets causes anaphylaxis in approximately half of the cases.⁷¹ Prednisone at a dosage of 2 mg/kg may be used to mitigate clinical symptoms. Preventative medication is mandatory in endemic areas.

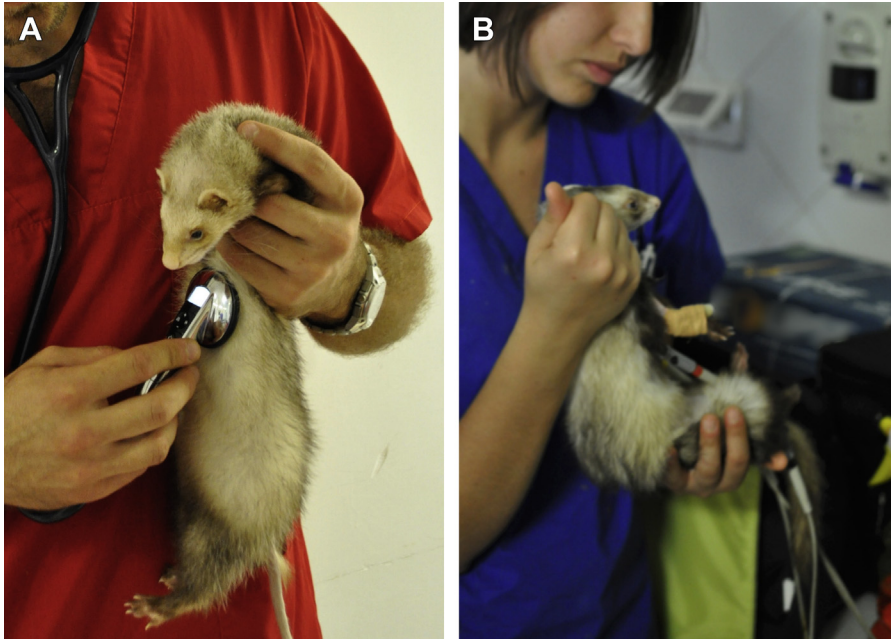


Fig. 38. Auscultation (A) and ECG (B) may be easier to perform in a vertical position in uncooperative ferrets.

Congenital Disorders

Congenital heart disorders are increasingly being diagnosed in ferrets (**Fig. 40**). Currently, ventricular septal defect, atrial septal defect, and tetralogy of Fallot are described in ferrets.^{66,72,73} Often the ferrets are asymptomatic until adulthood,

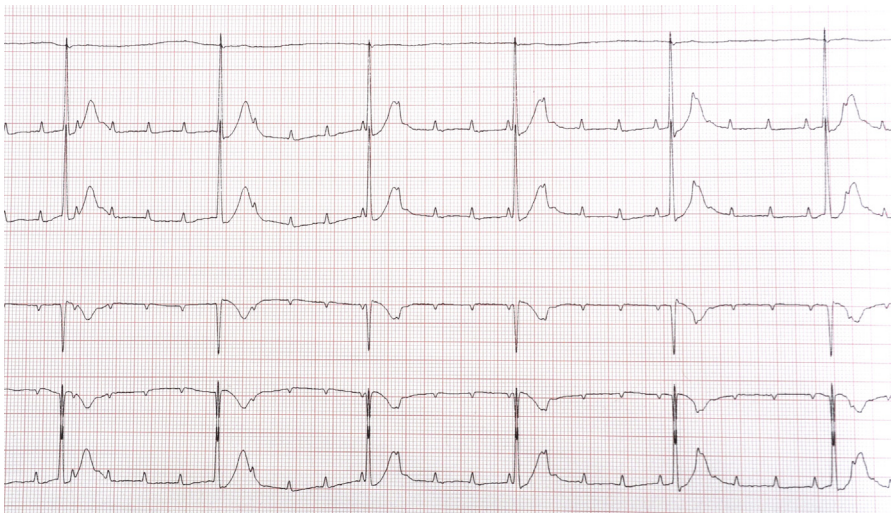


Fig. 39. ECG in a ferret with a third-degree ventricular block. Notice in lead II the dissociation of P waves and QRS complexes. The ventricular escape rhythm in ferrets is around 60 to 70 bpm.

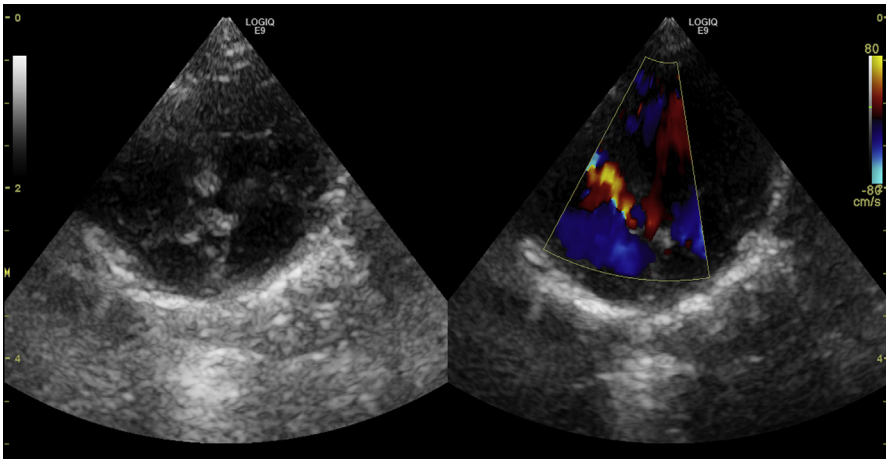


Fig. 40. Echocardiographic appearance of a ventricular septal defect in an asymptomatic ferret. A murmur was audible on auscultation. (Courtesy of Annalisa Nicoletti, DMV, Rome, Italy.)

when, as a consequence of severe heart remodeling, they develop CHF.^{66,73} Treatment is symptomatic, because surgical correction of congenital heart disorders in ferrets has never been reported.

Hypertension and Aortic Aneurysms

Systemic hypertension may be associated with CHF and renal disease, and blood pressure should be closely monitored in ferrets with cardiac disorders (Fig. 41, Video 6).⁷⁴ The practitioner needs to be aware that noninvasive blood pressure measurement (with manual sphygmomanometer and Doppler probe) underestimates blood pressure in ferrets.⁷⁵ However, it remains an affordable technique



Fig. 41. Noninvasive Doppler ultrasound blood pressure measurement in a conscious ferret. (Courtesy of Nicola Di Girolamo, Rome, Italy.)



Fig. 42. Dissecting aneurysm of the aorta in a ferret with severe systemic hypertension. Notice thickening of the tunica media and presence of erythrocytes in the vascular wall (*asterisk*). Inset: lateral radiograph of the ferret showing an area of increased opacity cranial to the heart consistent with the aorta (*arrow*). (Courtesy of Laura Bongiovanni, Teramo, Italy; and [*inset*] Nicola Di Girolamo, Rome, Italy.)

for blood pressure monitoring. As a rule of thumb, 30 mm Hg may be added after Doppler measurement (based on published data, mean difference: -28 mm Hg, 95% confidence interval approximately 4 to 60 mm Hg).⁷⁵ Systemic hypertension in ferrets may be secondary to causes similar to other domestic carnivores, including aldosterone-secreting adrenal tumors.⁷⁶ In cases of hyperaldosteronism, administration of spironolactone and amlodipine mitigates the hypertension.⁷⁴ Uncontrolled hypertension may result in dissecting aortic aneurism and sudden death (**Fig. 42**).

TRAUMA

Given the curious nature of ferrets, they tend to escape their enclosures and suffer accidents, including falling from windows or balconies, electrocution, washing machine-related injuries, and so on. Fractures in ferrets should be managed in a similar fashion as in other small animals. Spinal and pelvic fractures occasionally occur as a consequence of falling, and standard orthopedic treatment should be considered.⁷⁷ In general, standard diagnostic and therapeutic principles developed in small animal emergency medicine should be used in case of trauma.⁷⁸

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SUPPLEMENTARY DATA

Supplementary data related to this article can be found online at <http://dx.doi.org/10.1016/j.cvex.2016.01.006>.

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