

MEDICAL MANAGEMENT OF MEGACHIROPTERANS

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Abstract

The Megachiroptera includes a single family of fruit- and nectar-feeding bats, the Pteropodidae. Several species are endangered and many are threatened with extinction. The major disease concerns for captive management of megachiropterans are traumatic, nutritional and viral. Several important zoonotic viral diseases have recently been associated with megachiropterans.

Introduction

The following emphasizes important aspects of the medical management of megachiropterans; a more comprehensive review is forthcoming.⁶

The mammalian Order Chiroptera is subdivided into Microchiroptera and Megachiroptera. The Megachiroptera includes a single family of fruit- and nectar-feeding bats, the Pteropodidae, with 42 genera and 166 species.⁹ This family is confined to the subtropical and tropical regions of the Old World, east to Australia and the Caroline and Cook islands.¹¹ The term "flying fox" is generally applied to the large bats of the genera *Pteropus* and *Acerodon* while many of the other species are labelled "fruit bats."

The major disease concerns for captive management of megachiropterans are traumatic, nutritional and viral. When provided with appropriate nutrition and environmental requirements, these mammals are remarkably problem-free.

Rules and Regulations

In 1994 there were 12 megachiropteran species in North American zoological institutions. There are seven flying fox species listed on Appendix 1 of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES): Truk (*Pteropus insularis*); Marianas (*P. mariannus*); Ponape (*P. molossinus*); Mortlock (*P. phaeocephalus*); large Palau (*P. pilosus*); Samoan (*P. samoensis*); and insular (*P. tonganus*).⁷ All other megachiropterans belonging to the genera *Pteropus* and *Acerodon* are listed as Appendix 2.⁷

In the United States all *Pteropus* spp. are classified as injurious wildlife and, therefore, require a permit from the US Fish and Wildlife Service for their possession. This permit requires they be housed and transported in double-wired enclosures.

All bats require a permit from the Centers for Disease Control and Prevention (CDC) for importation and

movement within the United States.

Anesthesia

In island flying foxes (400-600 g) ketamine alone (30 to 37.5 mg/kg i.m.) produced short-term chemical restraint, but poor muscle relaxation and struggling during recovery.⁴ A xylazine (2 mg/kg i.m.) / ketamine (10 mg/kg i.m.) combination produced short-term immobilization (30 min) with good muscle relaxation and quiet recovery.⁴

Inhalation anesthesia is recommended for both short- and long-term restraint. Isoflurane (5% by mask decreased to 2.5% when relaxed) provides rapid (1-2 min) induction and recovery, as well as easily adjusted anesthetic depth. Megachiropterans > 350 g are intubated with a ≥ 2 mm internal diameter endotracheal tube. Good anesthetic relaxation and dorsal recumbency facilitate intubation. For visualization of the glottis, gauze is placed around the upper and lower jaws to open the mouth and the tongue is displaced forward. A laryngoscope with a small straight pediatric blade is used for illumination. Topical anesthetic applied to the glottal opening decreases reflex coughing. Glycopyrrolate (0.01 mg/kg i.m.) administered prior to induction will reduce the sometimes profuse pharyngeal secretions. Heart rate and rhythm, and peripheral blood flow are monitored with a Doppler flow probe secured over either the tibial artery behind the knee or the pedal artery on the palmar surface of the feet. Temperature is monitored using a probe placed in either the rectum or esophagus; the latter is preferred because it more accurately reflects core body temperature. To prevent hypothermia the wings are folded to the body, the animal placed on a circulating water blanket and where possible wrapped in either a blanket or bubble-wrap. Avoid electric or chemical heating pads which have caused severe burns. For recovery, bats are wrapped in a drape and left in a quiet cage to prevent struggling and wing-flapping; the animals are usually sufficiently recovered when they crawl out of the wrap.

Venipuncture

Venipuncture is facilitated by anesthesia. In megachiropterans ≥ 150 g large blood volumes are collected from the median artery or vein on the lateral aspect of the humerus. Small blood samples are collected into microhematocrit tubes from the cephalic vein, which extends along the leading edge of the patagium, and from pedal veins. The author prefers heparinized blood samples for biochemical analysis; this allows the blood to be centrifuged immediately after collection and the plasma removed from the blood cells and frozen until analysis. If the plasma remains in contact with the red cells for even a few hours there will be marked spurious elevations in potassium and decreases in sodium, chloride and glucose concentrations.

Preventive Medicine

All bats are examined at least once/yr. There are no currently recommended vaccinations. Parasite control is directed at detection and treatment, and appropriate and frequent sanitation of housing. For transport, the CDC requires that bats be free of rabies and *Histoplasma capsulatum*. Bats from captive collections should be quarantined a minimum of 90 days. During quarantine a minimum of three fecal flotations should be performed to detect nematode ova. Additionally, pooled rectal fecal samples are cultured for *H.*

capsulatum.

Parasitic Diseases

The nematode *Toxocara pteropodis* is found in south-east Asian and Australian flying foxes. Adult parasites live in the upper gastrointestinal tract of suckling pups.¹² Eggs passed in the feces of the pups are ingested by adult flying foxes during grooming and feeding.¹² Fertile eggs are ovoid to spheroid, 80-110 μm in diameter and the outer layer is pitted.¹³ The ova are bulkier than those of related ascaridoids because of a thicker external coat which, while not providing mechanical strength, is thought to protect against desiccation.¹³ The eggs hatch and the larva pass through the portal system to the liver where they encyst. In adult male bats the larvae do not develop any further. In the adult female bats the larvae are activated at the end of parturition and during lactation to migrate to the mammary gland where they pass in the milk to the suckling pup to complete the cycle. The adult worms are shed from the pup when it ceases to suckle and begins to eat solid food. There are usually only a few adult worms/pup (≤ 5) and they rarely cause morbidity or mortality. A captive island flying fox pup died from an intestinal volvulus associated with 20+ worms.³ Despite these examples, it is questionable whether it is necessary to treat *T. pteropodis* in captivity. *T. pteropodis* was once thought to be a possible cause of human hepatitis but this has subsequently been disproved.

Viral Diseases

Until recently there was very little information on megachiropteran viruses. However, recent events in Australia and Africa have precipitated an increased interest because of their suspected role in harboring several zoonotic viruses.

Lyssaviruses (Rabies). Bat lyssaviruses have been reviewed by Constantine.¹ Within the family Rhabdoviridae the genus *Lyssavirus* contains five serotypes: classic rabies virus (serotype 1), Lagos bat virus (serotype 2), Mokola virus (serotype 3), Duvenhage virus (serotype 4) and European bat virus (serotype 5).² All can cause rabies or rabies-like diseases in infected animals.² In 1996 in Australia a 5-month old female black flying fox (*Pteropus alecto*) was found under a tree unable to fly.² Histological examination of brain tissue revealed a severe nonsuppurative encephalitis. A second case, in 1995, was identified after retrospective examination of archived paraffin-embedded tissues.² The affected animal, a juvenile female of the same species, was reported to be more aggressive than usual and was euthanized. Although the encephalitis was very mild, many eosinophilic, cytoplasmic inclusion bodies were present in various parts of the brain. An indirect immunoperoxidase test for rabies performed on paraffin-embedded tissues using an antirabies monoclonal antibody showed positive reactions over wide areas of the brains of both bats. Additionally, similar reactions were observed in neuronal cytoplasm in gastrointestinal nerve plexuses. Electron microscopy examination of ultrathin sections of hippocampus from the 1996 bat showed aggregates of viral nucleocapsids within the cytoplasm of cell bodies. Virus was isolated from a weanling mouse injected with tissue homogenate. Sequence comparisons were done by using the nucleocapsid proteins of known lyssaviruses and the virus now designated pteropid lyssavirus. Phylogenetic analysis of both the nucleotide and amino acid sequences showed that the virus is closely related to the European bat virus as well as the classic street rabies strains. The virus has subsequently

been identified by immunohistochemical techniques in five bats in three different virus isolations.² Some of these bats were from another species, the little red (*P. subscapulatus*) and from locations as far apart as 1,700 km along the Australian east coast. Subsequent to the discovery of the virus in flying foxes the virus has been isolated from a Queensland woman in which the virus produced neurological disease, coma and death. The woman was a rehabilitation worker who was scratched by a sick fruit bat. Studies at CDC indicate that human, veterinary and sub-unit vaccines protect against the lyssavirus and sera of rabies-vaccinated people neutralizes the virus, as does hyperimmune reference sera.

Bat Paramyxovirus (Equine Morbillivirus). Two outbreaks of a previously unknown disease occurred in humans and horses in 1994 in Queensland, Australia.¹⁵ The outbreaks occurred within 1 mo of each other at two locations approximately 1,000 km apart. In one incident 14 of 21 infected horses died or were euthanatized because of severe acute respiratory disease. One of two humans with less well defined clinical signs also died. In the second incident, one person and two horses died. A paramyxovirus isolated from four of the horses and one human was designated equine morbillivirus. Serological sampling (neutralizing antibody) demonstrated antibody in all four Australian flying fox species; spectacled (*P. conspicillatus*), black (*P. alecto*), little red (*P. scapulatus*) and grey-headed (*P. poliocephalus*) with a prevalence rate of about 9%. A virus indistinguishable from equine morbillivirus and defined as bat paramyxovirus was subsequently isolated. This virus has not been associated with disease in either flying foxes or in persons who have had extensive exposure to bats. Research is ongoing into the biology of this virus and its mode of transmission. The author is working with Dr. Peter Young from Australia to perform a serological survey of the flying fox collection at the Lube Foundation. The author subsequently plans to coordinate compilation of samples from other collections in North America for testing.

Filoviruses (Ebola). Filoviruses are best known for their propensity to cause fatal hemorrhagic disease of humans with person-to-person spread.¹⁴ This lethality suggests primates are incidental victims of infection and not true reservoir hosts. To determine the possible source a wide range of vertebrates, invertebrates and even plants were injected with Ebola Zaire isolated from a human patient.¹⁴ This study was based on the principle that animals able to survive with circulating virus for prolonged periods without becoming ill were suspected reservoirs. The virus replicated in both microchiropteran and megachiropteran bats. Virus antigen was detected in the lung tissue of one bat and on day 21 from the feces of a megachiropteran (*Epomorphus wahlburgi*).

Kasokero (Yogue). A virus related to the unclassified virus Yogue was implicated as the cause of a mild to severe illness in four laboratory workers in Uganda.⁸ The virus was originally isolated by mouse inoculation from the blood of Egyptian fruit-bats (*Rousettus aegyptiacus*) collected from Kasokero cave in Uganda.⁸ Serological studies concluded the isolates from both bats and laboratory workers were strains of the same virus.

Nutritional

Nutrition is a major problem area in the captive management of bats. This is a reflection of bat diversity, limited knowledge of nutrient requirements, the small size of most bats and adaptation for flight.

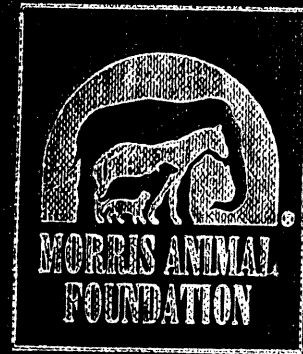
Hypovitaminosis E. Hypovitaminosis E has been associated with a dilated cardiomyopathy in flying foxes.⁵ The animals had been in captivity approximately 2-3 yr prior to the development of clinical signs. Significant findings included unmeasurable plasma vitamin E levels in affected bats and low to unmeasurable levels in many bats without dilated cardiomyopathy ($0.10 \pm 0.18 \mu\text{g/ml}$). Tissue levels of α -tocopherol were much lower in the affected than the unaffected bats. Additionally, γ -tocopherol levels were undetectable in affected bats. The diet was calculated to contain 56 IU/kg (dry basis) of vitamin E. Increasing dietary levels to $\geq 240 \text{ mg/kg}$ appeared to resolve the problem. An important natural source of vitamin E is green leaves. Although large flying foxes have traditionally been thought to feed exclusively on fruits and/or flowers, it has recently been shown that some species chew leaves and ingest the fiber-free juices.¹⁰ These leaves may be an important source of essential nutrients lacking in a purely frugivorous diet. Captive flying foxes have been observed crawling to the ground to consume or chew grasses.

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