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Pathology and Diseases of Great Apes at the National Zoological Park

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Knowledge of the diseases of great apes in captivity is essential for captive management of self-sustaining populations. This survey of medical and pathology records of orangutans, gorillas, and one chimpanzee at the National Zoological Park was conducted to provide a data base for improving health care of captive apes. Strongyloidiasis, balantidiasis, and entamoebiasis were recurrent problems in adult and juvenile apes of all species. Cardiac fibrosis also was prevalent in middle-aged apes and was a major cause of mortality. Bacterial infections were prevalent in perinatal orangutans and resulted in the death of two. For gorillas, rheumatoid arthritis associated with mycoplasma infections, and infertility were major problems. Because the pathogenesis of many of these lesions is unknown, survival of great ape populations in captivity may depend on future research on these problems.

Key words: Orangutan, gorilla, arthritis, infertility, cardiac disease

INTRODUCTION

Maintaining self-sustaining populations of great apes in captivity requires adequate numbers of mature individuals in good general and reproductive health. Keeping apes disease-free in zoological parks is challenging owing to their exposure to stresses and infectious agents from the proximity of the public and other species. Furthermore, providing natural habitats in zoos may improve psychological well-being but has posed new problems with sanitation and disease control because exhibits are more difficult to clean.

Most populations of great apes in zoological parks are small, so data on disease problems have been limited. This information gap hampers efforts to improve medical care and preventive disease programs for these species. The purpose of this report is to provide additional information on the disease problems of great apes through a retrospective survey of diseases at the National Zoological Park (NZP).

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MATERIALS AND METHODS

The medical and pathology records at the NZP were reviewed. Pathology reports from apes at NZP and on loan to other zoos included necropsy reports for one gorilla, 10 orangutans, and one chimpanzee and 13 biopsy reports. Medical records from 11 gorillas and 19 orangutans were examined.

RESULTS

Diseases of Orangutans

Three disease problems were prominent in orangutans: gastrointestinal parasitism, cardiac fibrosis, and perinatal bacterial infections.

Recurrent gastrointestinal parasitism, particularly with *Strongyloides stercoralis, Balantidium coli, Giardia sp.*, and *Entamoeba sp.*, affected all orangutans. *Strongyloides sp.* hyperinfection was observed at necropsy in two orangutans and was considered the cause of death in one of these two while on loan to another zoo. Persistent diarrhea has been observed in several individuals. Fecal cultures for enteric pathogens and parasitic examinations in these individuals have been negative except for abundant flagellates.

A 4-year-old orangutan had persistent diarrhea and progressive weight loss without evidence of parasitism. Fecal analysis indicated malabsorption, and intestinal biopsy results demonstrated eosinophilic enterocolitis suggestive of dietary hypersensitivity. Clinical improvement in response to prednisone treatment supported this diagnosis. Citino et al. [1985] reported on this case in detail.

Cardiac fibrosis was present in 4 orangutans, which were aged 17, 24, 26, and 28 years. All cases had degeneration and atrophy of myocardial cells with intercellular fibrosis. Scattered hypertrophied myocytes were present. Occasional small foci of myocardiolysis with an associated mild inflammatory reaction also were noted. Fibrosis was most severe around the intraventricular branches of the coronary arteries. Two cases had extensive fibrosis with loss of myocardium compatible with death from cardiac arrest. The other two cases had moderate fibrosis.

Bacterial infections during pregnancy and in neonatal orangutans also caused serious health problems. One preterm fetus was aborted owing to bacterial placentitis. Severe systemic bacterial infections affected two neonates. *Escherichia coli* septicemia resulted in death of a 4-day-old infant owing to severe suppurative meningitis. Another infant had severe bacterial stomatitis and suppurative arthritis of an elbow and coxofemoral joint. Bacterial omphalitis was considered the origin of the infection in both these cases. The infant with suppurative arthritis later developed purulent otitis. Another infant had oral candidiasis.

Reproductive tract diseases included uterine adenomyosis in two females and extensive endometriosis involving the ovary, oviducts, and most pelvic viscera in another. The female with endometriosis also had a malignant granulosa cell tumor, and another female had a fibromatous polyp that was expelled from the genital tract during parturition. One 20-year-old male had clinical signs of posthitis. Genital lesions were not noted in any male orangutans at necropsy.

Traumatic lesions made up a large proportion of the clinical problems. Deep skin lacerations and bite-wounds often resulted from cagemate aggression, especially during estrus. One orangutan sustained such deep wounds that surgical treatment was

TABLE 1. Causes of death in orangutans at the National Zoological Park

Age	Sex	Cause of death	Other lesions
Fetus	M	Abortion/chorioamnionitis	
4 d	F	*E. coli* meningitis	Omphalitis
1 y	F	Accidental strangulation	
2 y	F	Strongyloidiasis	
14 y	M	Post-anesthetic	Traumatic wounds
14 y	M	Intestinal intussusception	
17 y	M	Cardiac arrest	Cardiac fibrosis, chronic active hepatitis, pulmonary edema
24 y	M	Cardiac arrest/postanesthetic	Cardiac fibrosis, glomerulonephritis, adrenal cortical atrophy
26 y	F	Peritonitis	Endometriosis, intestinal perforation, ulcerative colitis, cholecystitis with rupture, granulosa cell tumor
28 y	F	Pyelonephritis	Abortion, strongyloidiasis, peritonitis

required and post-anesthetic death resulted. A neonate developed a bony mass on his skull of possible traumatic origin.

Non-traumatic skin and subcutaneous lesions were observed in several individuals. Large subcutaneous masses, that sometimes were ulcerated and self-mutilated, have been observed in two male orangutans. In one case histopathological examination of the masses determined that they were of three types: lipomas, trichoepitheliomas, and circumscribed foci of subcutaneous calcification (calcinosis cutis). The lesions in the second case have not been characterized histopathologically. Impetigo-like vesicular lesions were observed on the face and lips of two juvenile and one adult orangutan; all three were varicella zoster and Herpes B viral antibody negative. Several other orangutans have had non-specific ulcerative dermatitis.

Miscellaneous diseases of orangutans included air sac abscesses in two individuals, glomerulonephritis in a 24- and a 26-year-old orangutan, one case of cholelithiasis with gall bladder rupture, and one of viral hepatitis similar to hepadnaviral hepatitis in humans. Many individuals also had slight positive reactions to both avian and mammalian tuberculin tests, although evidence of tuberculosis within the orangutan population was lacking both clinically and at necropsy. These reactions were attributed to exposure to other non-pathogenic atypical mycobacteria.

Causes of Death in Orangutans

The causes of death in 10 orangutans are listed in Table 1. One fetal, one neonatal (<30 days), and two juvenile (<3 years) deaths accounted for 4 of 10 deaths. The adult female with pyelonephritis also aborted her fetus, suggesting that her infection ascended the urinary and reproductive tracts. The peritonitis in the 26-year-old female may have been caused either by perforation of the colon from aggressive pelvic endometriosis or by rupture of the gall bladder. Two cases of cardiac arrest were due to cardiac fibrosis.

Diseases in Gorillas

Many disease problems in gorillas were similar to those in orangutans. However, the major diseases of the gorilla collection at NZP were arthritis, infertility, and gastrointestinal disease. Strongyloidiasis and balantidiasis were identified, although

the prevalence and severity of these diseases were less than in orangutans. Infestation with *Entamoeba histolytica* and *Giardia sp.* also was noted. Two cases of shigellosis were observed. Diarrhea was a persistent problem in many individuals, but in most cases no bacterial or parasitic pathogens could be identified.

Gorillas were unique among the great apes for their propensity to develop a rheumatoid-like arthritis. Four gorillas at NZP had clinical arthritis; 3 of these 4 and 1 other gorilla were positive for rheumatoid factor. Complement-fixing antibodies to several *Mycoplasma sp.* (*M. tomoka*, *M. galinorn*, *M. pneumonia*, *M. laidlawi*, *M. ovale*, and *M. salivarium*) were identified in most, and increased gamma globulins were noted. *M. salivarium* was cultured from one severely affected gorilla, and mycoplasma antigens were identified in synovial tissues. These gorillas subsequently responded to prolonged low-dose treatment with tetracycline.

Infertility was a major problem in all gorillas. Fibrous peritoneal adhesions were observed by laproscopy in 3 female gorillas, but the adhesions involved the uterus and ovaries in only 1 of 3 and did not occlude her oviducts. Pelvic inflammatory disease due to prior endometritis was suspected, although endometrial biopsy results indicated the endometrium was quiescent with no evidence of inflammation. Adhesions in the other two were between the small intestines and the abdominal wall or between liver, stomach, spleen, and upper small intestines. Trauma was proposed as the cause.

Non-cycling, anovulatory ovaries were observed by laproscopy in 4 of 4 females. No uterine abnormalities were noted. Hypothalamic dysfunction, possibly associated with obesity, was suspected as the cause of ovarian inactivity. However, hypothalamic/pituitary functions were not assessed.

Male infertility also was prevalent. Semen evaluation of four males indicated low semen volumes with low-to-no motile sperm and 85–95% abnormal spermatozoa [Raphael et al., 1989]. Testicular biopsy results from one male with poor semen quality were reported as testicular degeneration. Biopsies from other males were not available.

Upper and lower respiratory infections affected many individuals. A definitive diagnosis was not obtained for most of these infections, although *Salmonella sp.* was isolated from one case of severe pharyngitis. Another gorilla had multiple submandibular cutaneous fistulous tracts from which *Salmonella sp.* also was isolated.

Miscellaneous diseases identified in individuals include allergic conjunctivitis associated with bedding changes, a gastric ulcer, a case of glomerulonephritis and one of mild hydrocephalus with ataxia that eventually resolved. Traumatic lacerations and bite wounds from cagemate aggression were as prevalent in gorillas as in orangutans. Mild tuberculin reactions also were observed in the gorilla population with no clinical evidence of tuberculosis.

In the single gorilla death, the cause of death was not identified. Hemosiderosis of multiple organs, fatty degeneration of the liver, moderate renal oxalosis, and severe islet cell hyperplasia were the histological findings. Cardiac muscle was not examined histologically.

Diseases in a Chimpanzee

The single chimpanzee death was ascribed to cardiac arrest due to cardiac amyloidosis and fibrosis. Hepatic, splenic, renal, and testicular amyloidosis also was present. The amyloid was AA type, consistent with reactive amyloidosis (Dr. Jorges Ribas, personal communication).

DISCUSSION

Gorillas and orangutans have been successfully maintained at NZP with few major disease problems. Awareness of potential problems, such as gastrointestinal parasitism, has resulted in successful preventive disease programs; determination of the basis for other problems, for example rheumatoid arthritis, has resulted in specific and effective treatments. However, the problems of infertility in gorillas and cardiac fibrosis in orangutans persist, due to a lack of understanding of the pathogenesis of these problems.

Strongyloides stercoralis infestation can be fatal in all great apes owing to severe and extensive larval migration following hyperinfection [Harper, 1982; Penner, 1981]. Two unique aspects of the life-cycle of this parasite contribute to massive parasitic burdens: a prolific, parthenogenic, free-living female produces high levels of environmental contamination, and conversion of first-stage larvae to infective third-stage larvae within the intestinal tract results in hyperinfection of individuals through larval penetration of the large intestinal wall [Soulsby, 1968]. Therefore, hyperinfection can occur without the diagnostic aid of larvae in the feces. An ELISA test for larval antigens in humans, which has been modified for monkeys, may assist in diagnosis of occult cases [Neva, 1981]. The preventive health program at NZP includes frequent anthelmintic treatment to avoid hyperinfection. The orangutan that died of strongyloidiasis was on loan to another institution and had not been treated. At NZP and at other facilities [McClure et al., 1973; Uremura et al., 1979], orangutans appear to be more susceptible than other apes. Harper [1982] has suggested that orangutans may have less innate resistance to infection because they would have had little exposure in the wild, being arboreal and often solitary. Fatal cases of strongyloidiasis also have been reported in gorillas [Benirschke and Adams, 1980; Penner, 1981]. Entamoebiasis and balantidiasis also can produce severe disease in great apes through penetration of the intestinal wall [Soulsby, 1968; Benirschke and Adams, 1980].

Cardiac fibrosis, which was observed in orangutans and a chimpanzee at NZP, has been reported in gorillas [McNamara et al., 1987] and in a chimpanzee [Hansen et al., 1984]. This lesion is similar histologically to chronic ischemic heart disease (CIHD) in man [Robbins et al., 1984]. Cardiac arrest without premonitary signs, often associated with an anesthetic procedure, has been noted in man [Robbins et al., 1984] and great apes with this lesion. The problem in great apes may be more prevalent than currently recognized. In our survey, cardiac tissue was not available for two additional sudden deaths, including a postanesthetic death. Also, in the review by Benirschke and Adams [1980] several gorillas had heart weights above average, consistent with a proliferative or infiltrative process of the myocardium. In man, CIHD occurs through chronic progressive ischemia, resulting in myocytolysis, myocardial fiber atrophy, and subsequent deposition of interfascicular fibrous tissue (scarring) [Robbins et al., 1984]. Ischemia in man is caused by progressive occlusion of coronary vessels with atherosclerosis [Robbins et al., 1984]; however, in apes, atherosclerotic lesions are absent or minimal despite reported high cholesterol levels [Benirschke and Adams, 1980]. Furthermore, CIHD in man is a disease of the elderly, whereas cardiac fibrosis affects great apes in midlife (13–28 years). McNamara [1987] has proposed that cardiomyopathy due to hypovitaminosis E resulted in cardiac fibrosis in two gorillas.

In the chimpanzee, cardiac fibrosis was accompanied by cardiac and systemic amyloidosis. The tissue distribution in the chimpanzee parallels reactive systemic amyloidosis in man, which is associated with chronic inflammatory disease [Kisilevsky, 1983]. However, no chronic or acute inflammatory process was identified in the chimpanzee.

Infertility in gorillas at NZP has been ascribed principally to gonadal hypofunction of endocrine origin, although the specific case has not been identified. In females, it is unlikely that peritoneal adhesions interfered with fertility, because adhesions did not involve the reproductive tracts of two females and did not obstruct the oviducts in another female. One orangutan female also had severe pelvic adhesions, but these were due to endometriosis, a problem that has not been documented in NZP gorillas. In nonparous women, endometriosis is common and is a major cause of pelvic adhesions and infertility [Clement, 1987]. Endometrial adenomyosis, in contrast, occurs in older multiparous women and is not associated with infertility [Zaloudek, 1987]; orangutans with this lesion had similar histories.

In male gorillas, testicular atrophy was noted at NZP and has been reported previously [Steiner et al. 1985; Benirschke and Adams, 1980]. As in females, the cause of gonadal hypofunction is unknown.

Perinatal bacterial infections in orangutans could have occurred from infections in utero, during delivery, or postnatally. Routine histological examination of all placentas may assist early diagnosis and treatment of prenatally infected infants, improving their survival rate. The absence of neonatal problems in gorillas in our survey reflects their infertility, rather than more viable offspring for this species.

The progressive destructive arthritis involving multiple joints in gorillas is similar to rheumatoid arthritis in man [Robbins et al., 1984]. The association between mycoplasma infections and rheumatoid arthritis in gorillas has been reported in depth by Brown et al. [1978]. Presence of rheumatoid factor in affected individuals and clinical response to tetracycline supports these observations. Why other ape species are unaffected is unknown.

Miscellaneous disease problems in orangutans and gorillas, such as ulcerative dermatitis and glomerulonephritis, are not unique to great apes. Most of these diseases did not have a specific etiologic cause and, because they had low prevalence (usually only individuals affected), were not considered major disease problems of captive great apes. Airsacculitis [Cambre et al., 1980] and false-positive TB tests [Miller et al., 1984] have been reported in other zoos.

CONCLUSIONS

This survey identified areas of major and minor health problems in orangutans and gorillas in a zoological park.

1. Strongyloidiasis, balantidiasis, and entamoebiasis continue to produce significant disease in great apes. Sanitation and frequent anthelmintic treatments can control these problems.
2. Cardiac fibrosis is prevalent in middle-aged great apes and may be a significant cause of sudden death and postanesthetic death due to cardiac arrest. Investigations into the cause of this disease are warranted.

3. Bacterial infections in perinatal orangutans were an important cause of morbidity and mortality. Most infections originated from bacterial omphalitis.

4. Infertility in gorillas did not appear to be due to degenerative, dysplastic, or infectious processes of the reproductive tract. Gonadal hypofunction was the most consistent finding.

5. Rheumatoid arthritis affected many gorillas and was associated with mycoplasma infections.

It is hoped that identification of these problems will set investigative directions for research in great ape diseases and will serve as the basis for improved health care in zoological parks.

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