Cerebellar Herniation in Captive Lions (*Panthera Leo*)

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Cerebellar herniation in captive lions (*Panthera leo*)

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Cerebellar defects are among the more common developmental anomalies of the nervous system in domestic animals and are almost invariably accompanied by significant and distinctive clinical manifestations. Cerebellar lesions are either due to a primary developmental malformation or hypoplasia secondary to an in utero or perinatal viral infection. Developmental malformations of the cerebellum include the Arnold–Chiari malformation and the Dandy–Walker syndrome.[15]

Bone thickening of the cranial vault with cerebellar herniation has been reported in captive and wild-caught lions in zoological collections in Australia,[11] Europe,[1,14,16] and South Africa.[2] The affected animals exhibited ataxia, disturbed equilibrium, staring expression, opisthotonus, and apparent blindness with development of convulsions prior to death. Some of the authors considered the disease was due to dietary deficiency of vitamin A.[1,2,11] This paper records a series of cases from a single facility, and the possible roles of vitamin A and other factors in the etiology are discussed.

Eight lions of various ages but less than 2 years old maintained in a closed pride at a zoological park (Lion Country Safari, West Palm Beach, FL) had periodic neurologic problems consisting of incoordination, opisthotonus, and head tilt spanning approximately 6 years. Table 1 lists the animals involved in this study. The diet consisted of raw chicken supplemented with calcium carbonate powder and multivitamin preparations.[a] The affected lions were treated with corticosteroids, B complex vitamins, taurine, and antibiotics with no improvement in clinical signs, so the lions, except lion 2, which died, were euthanized. The necropsies were conducted at the University of Florida, Veterinary Medical Teaching Hospital (VMTH), Gainesville, Florida, except for lions 6, 7, and 8, which were examined by the referring veterinarian. In addition to these 8 lions, tissues from a 1.5-year-old female lion from the same facility with neurologic signs were submitted by the referring veterinarian, but because of freezing artifacts, these tissues were not included in this study. Tissues obtained at necropsy were fixed in 10% neutral buffered formalin, embedded in paraffin, sectioned at 5 μm, and stained with hematoxylin and eosin (HE) or luxol-fast blue.

Lion 1 developed recurrent problems with ataxia and vestibular disease a few months after birth. Neurologic examination suggested bilateral vestibular disease with a slight head tilt to the left. Cerebrospinal fluid and electromyogram were within normal limits. At necropsy, the osseous tentorium cerebelli was markedly thickened with a central 4- × 3.5- × 3-cm irregular hard knob continuous with the markedly thickened occipital bone. The protuberance was located between the posterior aspect of the cerebrum and the cerebellum and compressed the cerebellum and reduced the size of the cerebellar fossa. There was mild dorso-ventral flattening of the cerebral hemispheres. The ventral third of the cerebellar vermis was flattened, with a lip-like projection extruding from the vermis and resting on the medulla (Fig. 1). The fourth ventricle and medulla were elongated and extended beyond the foramen magnum. Lion 2 was a weak, month-old female cub that had poor weight gain and developed a head tilt at 3 weeks of age. Skull radiographs, retinal examination, and otic examinations were conducted at VMTH and were found to be within normal limits. The cub died, and at necropsy, removal of the tentorium cerebelli was difficult. Gross changes at necropsy were similar to those of lion 1. Lions 3, 4, and 5 were littermates with neurologic signs consisting of progressive ataxia, head tilt, and loss of orientation of variable severity. Toxoplasma, FIV, and FeLV tests were negative, and CBC and serum chemistry were within normal limits. The cubs were euthanized and necropsies were performed at the VMTH. Similar lesions were present in the 3 cubs, with a thick, nodular osseous tentorium cerebelli (Fig. 2) and reduction in posterior fossae with dorso-ventral compression of the cerebellum. A portion of the caudal cerebellar vermis was markedly flattened, with a peg-like projection that extended beyond the foramen magnum (Fig. 3). In addition, cubs 4 and 5 had elongation of the fourth ventricle and displacement of the choroid plexus. Sagittal section of the cerebral hemispheres revealed mildly dilated lateral ventricles.

Archival reports from the VMTH revealed 3 other lions, lions 6, 7, and 8 from the same collection, that showed neurologic signs. These lions were euthanized and necropsied by the referring veterinarian, and tissues were submitted to the VMTH. No gross lesions were noted. Lion 6 was a 1.2-year-old female that had recurring problems with orientation, rolling with its head up, bellowing, and progressive difficulties in swallowing and defecating. Keepers noted that the lioness had never behaved completely normally since birth. Lion 7 was a 1.2-year-old male with incoordination and opisthotonus for approximately 2–3 months. Skull radiographs, serum chemistries, and CBC were within normal limits. Lion 8 was a 1.5-year-old female with recurring equilibrium problems, and often the animal would lose its balance when it became excited and would run blindly into objects and fall.

The brains and spinal cords of all the lions except lion 8 were examined in detail. Histologic lesions of the central

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Table 1. Summary of lions involved in study of cerebellar herniation (*Panthera leo*).

Lion no.	Sex	Age
1	M	1 yr
2	F	1 mo
3*	F	3 mo
4*	F	3 mo
5*	M	3 mo
6	F	1.2 yr
7	F	1.5 yr
8	M	1.2 yr

* Littermates.

nervous system were primarily confined to the herniated portions of the cerebellum and spinal cord in all lions. Changes were marked in the herniated folia and consisted of thinning and rarefaction of the molecular layer, patchy-to-coalescent loss of Purkinje cells, granular cells, and proliferation of Bergmann glia (Fig. 4). In the most severely affected folia, demarcation between the layers was lacking and the residuum had marked glial proliferation (Fig. 5). The aqueduct was patent in all examined sections. The central medullary canal was irregularly dilated and dissected into the surrounding parenchyma with circumferential mild astrogliosis. White matter tracts in the medulla and, to a lesser extent, in the pons had Wallerian degeneration characterized by dilation of axon sheaths, axonal spheroids, and digestion chambers with Gitter cells. This change was often bilaterally symmetrical. Leptomeninges from the dorsal medulla to the cranial spinal cord were multifocally thickened by fibrous tissue (Fig. 5).

In the anterior cervical spinal cord (lions 6 and 7), there was dorsoventral compression of the dilated central canal with segmental attenuation of the ependymal cells. The entire dorsal funiculus was rarefied with scattered loss of axons and mild demyelination. In addition, all lions had mild axonal degeneration in the ventral and lateral funiculi of the spinal cord. The change was prominent in the cervical segment of the cord, especially at the cervico–medullary junction. The thoracic and lumbosacral cord had similar mild changes. Sections of the cerebrum in all lions were essentially normal except for minimal-to-mild subependymal astrogliosis. Sections of the eye and peripheral nerves (only lions 1, 2, and 6) were essentially normal.

The occipital bone and the tentorium cerebelli osseum (lions 1 and 2) were thicker than expected, with closely spaced spicules of woven and lamellar bone separated by fat. A thick layer of dense fibrous connective tissue with a deeper layer of distorted cartilage columns displaying endochondral ossification covered the free edge of the tentorium. The central core of the tentorium had large irregular islands of fibrocartilage and woven bone with retained cartilaginous

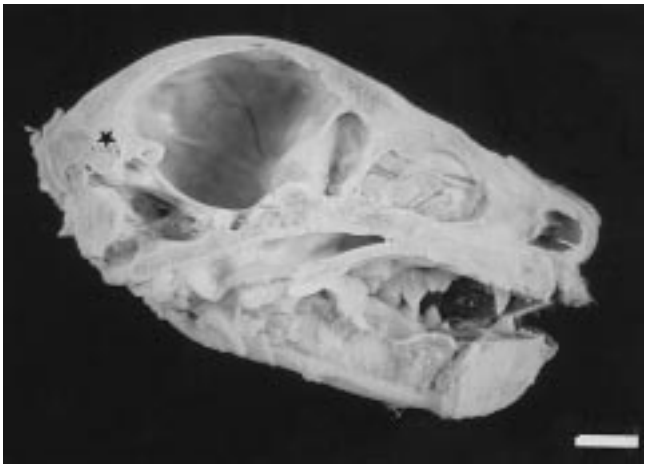

Figure 2. Midline sagittal section of the skull of lion 3. The posterior fossa is small. Note thickening of the occipital bone and osseous tentorium cerebelli (★). Bar = 1.2 cm.

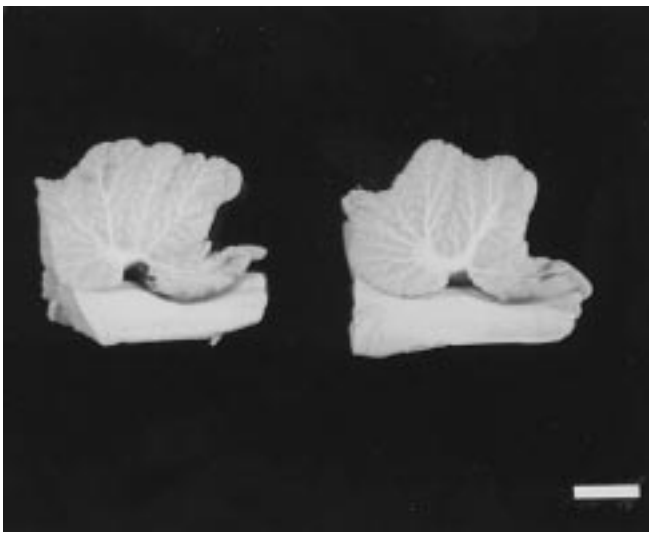

Figure 1. Midline sagittal section of the cerebellum of lion 1. Herniation of the vermis is evident. Bar = 1 cm.

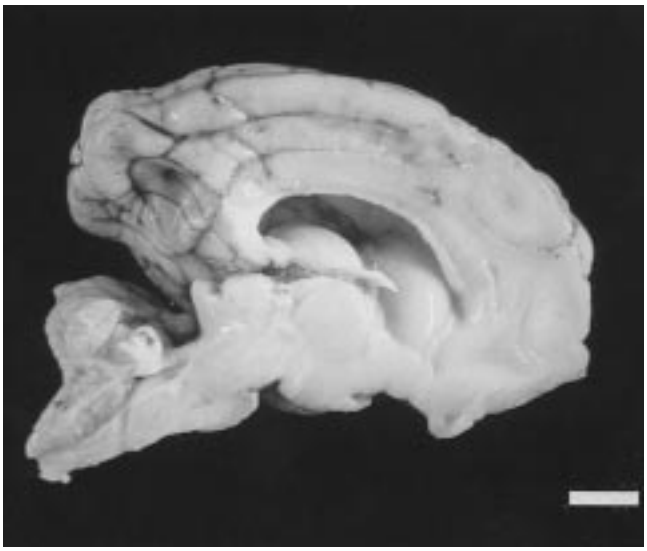

Figure 3. Midline sagittal section of the brain of lion 3. Note dorsoventral compression of the cerebellum and herniation of the vermis. Bar = 1.2 cm.

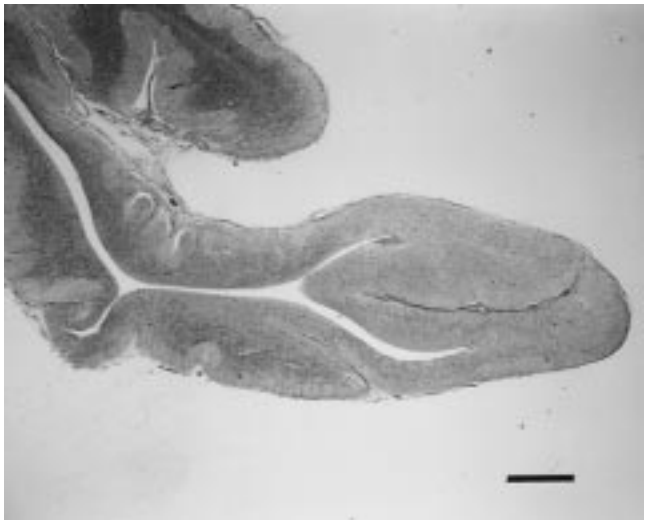

Figure 4. Low magnification view of the herniated cerebellar folia. Note loss of distinction between layers of the folia. HE. Bar = 700 μm.

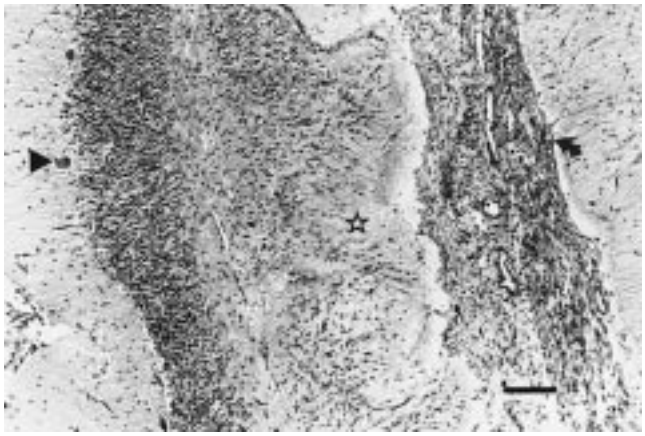

Figure 5. Atrophic herniated folium with severe depletion of granular and Purkinje cells with gliosis (★). A few remnant Purkinje cells are present (arrowhead). Note the marked fibrous thickening in the interfolial sulci (curved arrow). HE. Bar = 30 μm.

cores (Fig. 6). Osteoclasts were rare in the examined sections of bone from the skull.

Similar thickened bones of the cranial vault with cerebellar herniation has been reported in captive lions with suspected vitamin A deficiency from other parts of the world.[1,2,11,14,16] The investigators considered that the condition was in part or totally due to hypovitaminosis A on the basis of the low levels of vitamin A in the livers of some of the affected lions.[1,2,11] Vitamin A levels were not assayed in any tissues of the lions or in their feed in this study.

Vitamin A deficiency leading to the development of neurological disorders has been reported in several domestic animals and birds. The distinctive gross lesions of cranial bones and nervous tissues described in this report and observed by others in lion cubs have been produced experimentally in vitamin A-deficient puppies,[9,10] and similar lesions are associated with vitamin A deficiency in calves[3,12] and pigs.[4,12] Vitamin A deficiency in calves results in doming of the frontal bone area, and thickening of the squamous occipital, basisphenoid, and presphenoid bones; the lesion is also seen in neonatal calves from vitamin A-deficient dams. Compression of the brain with herniation of the cerebellar vermis is frequently observed.[3,12,15] Pigs with vitamin A deficiency have osseous thickening of the tentorium cerebelli, cerebral edema, and herniation of the cerebellar vermis.[4,12] Vitamin A deficiency in birds is also characterized by herniation of the cerebellum or other areas of the CNS and concomitant bone lesions.[7,8] In contrast, domestic kittens, 3–6 months old, fed vitamin A-deficient diets experimentally failed to develop the clinical signs or lesions noted in the lions, which may because of adequate hepatic reserves prior to the start of the experiment or a slower rate of growth in domestic cats compared with the lions.[6]

The pathogenesis of increased thickness, especially of bones of the cranium, has not been completely elucidated. Normally, osteoclasts are responsive to vitamin A, and in the cranium of deficient animals there is inadequate resorption of endosteal bone.[4] Often bone is produced at sites where resorption should be occurring.[4]

Skull malformation and cerebellar herniation were not observed in lions 6, 7, and 8 but may have been overlooked. Excessive ossification of the osseous tentorium cerebelli has been considered to be a normal finding in Felidae.[14] However, we did not observe this change in a skull from a normal lion from the Florida Museum of Natural History.

Vitamin A deficiency may not have been the sole cause of the syndrome described in this study. Possibly a genetic basis for the condition was occurring in the closed captive herd. Two of the 4 cases previously reported in lions were from the same litter.[1,14] Similarly, lions 3, 4, and 5 in our report were from the same litter. The limited number of cases precluded attempts to establish the familial relationship of the lions in this study. On the contrary, cubs born to vitamin A-deficient dams may have received little, if any, vitamin A in the milk, thus affecting all the cubs in the litter, similar to reports of puppies and calves.[3,9,10,12]

The disease entity in these lions also had some similarities to Arnold–Chiari malformation, including herniation of the

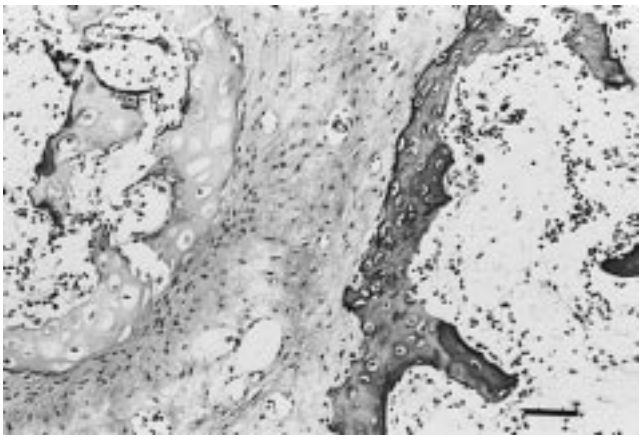

Figure 6. Osseous tentorium cerebelli with broad seams of fibrocartilage and woven bone. HE. Bar = 60 μm.

cerebellar vermis, elongation of the fourth ventricle, and reduction in the size of the posterior fossa.[5] However, an important difference is that higher grade Arnold–Chiari malformation in humans is associated with lumbar spina bifida and/or a protruding meningomyelocele. The clinical symptoms in human beings are often related to the presence of hydrocephalus.[5] Though mild dilation of the lateral ventricles was observed in 2 lions, this was not a significant feature. A part of the present study was previously reported as Arnold–Chiari-like malformation in an abstract form.[13]

In summary, the lions in this report had skull malformation and cerebellar herniation. Although the precise etiology of the described changes in these lions cannot be determined, the gross and histologic lesions have striking similarity to the lesions described in lions with vitamin A deficiency in other parts of the world.

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Arcanobacterium pyogenes as a cause of fatal pleuropneumonia after capture and transport of white-tailed deer (*Odocoileus virginianus*)

Mitchell V. Palmer, Diana L. Whipple

Arcanobacterium pyogenes (previously *Actinomyces pyogenes*) is a pyogenic, gram-positive, pleomorphic bacterium that can cause a wide variety of nonspecific suppurative lesions involving various visceral organs.[13] In the lung, abscessation usually begins deep in consolidated areas where alveolar tissues undergo necrosis. *Arcanobacterium pyogenes* produces a hemolytic, dermonecrotic exotoxin and a protease that may contribute to necrosis and suppuration.[8,15] Necrotic material may liquefy and be discharged into an airway so that a cavity remains.[3] Infection with *A. pyogenes* is often a sequel to earlier tissue injury or to infection with other bacteria. In Cervidae, *A. pyogenes* has been implicated in mastitis with subsequent disseminated disease,[16] intracranial abscesses,[2,6] chronic fibrinopurulent bronchopneumonia with abscessation,[10] necrobacillosis,[17] foot abscesses,[5] metritis, endocarditis, and abortion.[11]

Thirty-eight pregnant does were obtained from a

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