Journal of the American Association for Laboratory Animal Science
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Vol 46, No 5
September 2007
Pages 72–74

Congenital Radial and Thumb Aplasia in a Neonatal Owl Monkey (*Aotus nancymaae*)

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This report describes congenital radial and thumb aplasia in a neonatal owl monkey. Congenital limb deformities in human neonates and Old World primate species have been well characterized. The many probable causes of these congenital defects in skeletal structure include fetal exposure to environmental toxins and genetic influences. In nonhuman primates, the cause frequently remains undetermined. In the case we present, the neonate presented for examination because of inability to cling to the dam. The forelimbs were contracted distally, and thumbs were absent. Radiographs indicated complete radial aplasia and other skeletal abnormalities. This description is the first case study of congenital radial and thumb aplasia in a New World primate species.

Congenital malformations in mammals have been linked to a variety of factors, such as genetic defects and exposure of the dam to environmental toxins or teratogenic drugs. Limb deformities, including skeletal malformations and polydactyly, in *Macaca* spp have been described.[2,8] One published report suggested that 14% of infants in a free-ranging group of *Macaca fuscata* had congenital limb deformities including absence of the limbs and digits.[8] Polydactyly in Old World primates has been particularly well characterized,[2] with relatively few instances in New World species. The etiology of limb and digit deformities in monkeys has not been determined, although both genetic defects and environmental toxins have been postulated.

Baboon embryology and teratology have been well characterized. The baboon embryo seems to be most sensitive to teratogens, such as thalidomide, which cause limb deformities between days 25 and 29 of gestation.[5] This timing is consistent with the sensitive period for the development of limb defects in macaques.[4]

In the human literature, radial insufficiency and thumb hypoplasia are well described.[6,9] This defect is characterized by underdevelopment and shortening of the forearm and is often associated with thumb and first metacarpal aplasia. Carpal bones are either hypoplastic or absent. Congenital longitudinal deficiencies of the radius and thumb are closely linked in the human population, with the severity of the thumb deficiency directly proportional to that of the radial deficiency. Bilateral involvement occurs in 64% to 72% of cases, with a prevalence of 1:30,000 to 1:100,000.[6]

Case Report

This report describes a congenital limb deformity in a New World primate. A male owl monkey (*Aotus nancymaae*) was born at the Center for Neotropical Primate Research and Resources (Mobile, AL). The dam and sire of this infant were housed in an indoor facility, and both were colony-born monkeys that had originated from a commercial research laboratory. This pair was part of the owl monkey breeding colony at the Center; these animals were not part of an experimental protocol. This particular breeding pair has had 3 previous live births and, to our knowledge, no abortions. Two of the progeny are now young adults and are paired with mates. Neither offspring has had any offspring, but this outcome is not unexpected in light of their ages. The third infant was born healthy but later was euthanized due to failure to gain weight; at necropsy, this infant had no congenital anomalies.

Figure 1. Dorsoventral radiographic view of the neonatal owl monkey displaying abnormal forelimb position and function. Both forearms are contracted abnormally, and thumbs are absent from both hands. Mild scoliosis is present, and the tail is kinked between vertebrae. This infant presented with an inability to cling to the dam.

All owl monkeys at the Center are fed a commercial diet (Zu-Preem Monkey Diet Canned, Premium Nutritional Products, Mission, KS, and Fiber-Plus Monkey Diet 5049, LabDiet Purina, St Louis, MO) and seasonal produce. The diet also is supplemented with daily treats (PRIMA-Treats, Bio-Serv, Frenchtown, NJ). All procedures are in accordance with the Institutional Animal Care and Use Committee of the University of South Alabama.

The neonate was examined at birth because of inability to cling to the dam. On initial examination, the infant monkey was bright, alert, and responsive. However, he was unable to grip normally with the forelimbs. Thumbs were absent from both hands. The thoracic limbs appeared shortened and contracted distally. In addition, the tail was kinked between several vertebrae. Physical exam revealed no other abnormalities. Radiographs obtained of the neonate (Figure 1) indicated

Received: 11 Apr 2007. Revision requested: 2 May 2007. Accepted: 9 Jun 2007.
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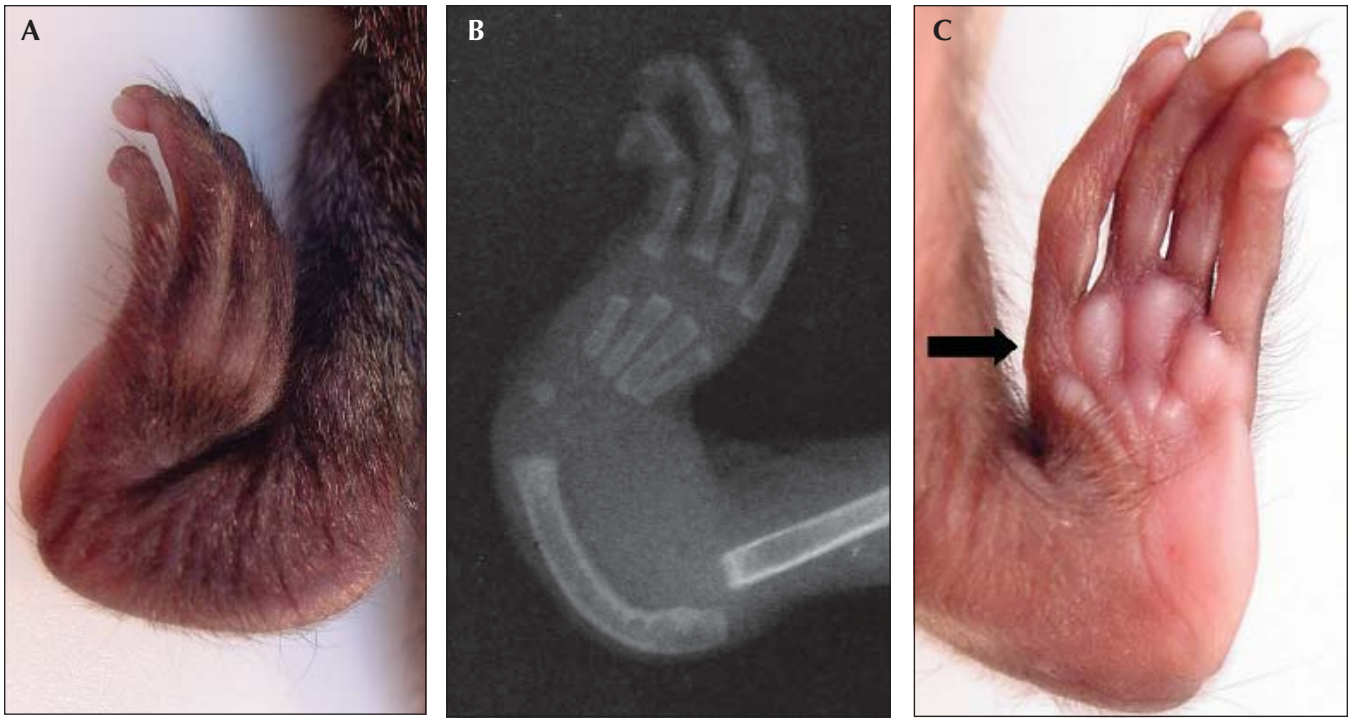

Figure 2. (A) Photograph and (B) radiograph of the left forelimb of the neonatal owl monkey. Note the abnormal curvature of the ulna and complete absence of the radius. (C) Photograph of the palmar surface of the left hand. The thumb is completely absent. An arrow indicates where the thumb should be located.

complete radial aplasia (Figure 2), absence of both thumbs, and kinks (appearing between the vertebrae) in the tail. The infant also had mild scoliosis. The clinical findings and radiographic findings were consistent with multiple congenital anomalies.

This animal was euthanized because it could not adequately cling to the dam. Ability to grip is essential for survival in owl monkeys because they are arboreal animals that use vertical space even in captivity.

Discussion

We noted multiple anomalies in the presented monkey. Radiographically, we identified distal curvature of the ulna, concurrent with radial aplasia, as well as aplasia of the thumb and first metacarpal bones. Only 2 carpal bones are visible on the radiograph, but this appearance is not unusual for a neonatal owl monkey.[3] Carpal abnormalities and deficiencies frequently are associated with radial aplasia and thumb aplasia in children, but these anomalies cannot be assessed fully until 8 y of age, when the carpal bones have fully ossified.[6] The presence of carpal bones in our owl monkey infant was confirmed at necropsy and again by histopathology but could not be fully evaluated because of young age. In primates, radial insufficiency has been linked to experimental fetal exposure to toxins, specifically thalidomide but also valproic acid and trans retinoic acid and presumably others.[4,7] In humans, radial insufficiency and thumb hypoplasia have been associated with both fetal exposure to toxins[9] and to genetic anomalies and syndromes.[6,9] In people, radial deficiency is commonly linked with several other conditions including congenital heart malformation or conduction defects (Holt–Oram syndrome), thrombocytopenia, Fanconi syndrome, and the VACTERAL (vertebral abnormalities, anal atresia, cardiac anomalies, tracheoesophageal fistula, renal abnormalities, radial abnormalities, lung anomalies) syndrome.[6] This infant monkey had only mild scoliosis in conjunction with severe bilateral radial and thumb deficiencies; gross necropsy and histologic evaluation revealed no other abnormalities.

In the laboratory animal setting, mouse breeding colonies dewormed with mebendazole will have a high incidence of 'kinky tails' in the offspring.[1] Unlike those in the neonate we present, the mebendazole-associated kinks in mouse tails occur within the vertebral bones and are not between vertebrae. We routinely deworm *Aotus* monkeys in our breeding colony with fenbendazole, a drug of the same class (benzimidazole derivatives) as mebendazole, and this dam was treated with fenbendazole (75 mg/kg body weight orally once daily for 3 d; Panacur, Intervet, Millsboro, DE) multiple times during her pregnancy. In studies of baboon teratology, the fetus is particularly susceptible to limb abnormalities from days 25 to 29 of gestation.[4] This timeframe correlates to days 19 to 22 of the gestation period in owl monkeys. Given the frequency of fenbendazole deworming in our owl monkey colony, the dam likely was treated during a potentially sensitive period. Although no previous reports of congenital anomalies after exposure of fetal primates to fenbendazole have been published, the possibility that exposure to a drug like fenbendazole or an environmental toxin played a role in this case cannot be ruled out. However, as is the case with human congenital radial and thumb aplasia, we speculate that a genetic cause is more likely.[6]

This case report is the first published report of radial aplasia in a New World primate species. Because we were unable to determine a specific cause for the abnormalities in this case, we consider this instance of multiple congenital defects as idiopathic.

Acknowledgments

This publication was partially supported by grants K01 RR021971 (to AMS) and R24 RR020052 (to CRA) from the National Center for Research Resources, National Institutes of Health. Its contents are solely the responsibility of the authors and do not necessarily represent the official views of the NCRR or NIH.

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