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Struvite Penile Urethrolithiasis in a Pygmy Sperm Whale (*Kogia breviceps*)

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ABSTRACT: Massive urolithiasis of the penile urethra was observed in an adult pygmy sperm whale (*Kogia breviceps*) stranded on Topsail Island, North Carolina, USA. Calculi occupied the urethra from just distal to the sigmoid flexure to the tip of the penis for a length of 43 cm. A urethral diverticulum was present proximal to the calculi. The major portion of the multinodular urolith weighed 208 g and was 16 cm long × 3.7 cm diameter at the widest point. The urolith was composed of 100% struvite (magnesium ammonium phosphate) and on culture yielded *Klebsiella oxytoca*, a urease-positive bacterium occasionally associated with struvite urolith formation in domestic animals. Reaction to the calculi was characterized histologically by moderate multifocal to coalescing plasmacytic balanitis and penile urethritis. Role of the urethrolithiasis in the whale's stranding is speculative but could have involved pain or metabolic perturbations such as uremia or hyperammonemia.

Key words: *Kogia breviceps*, pygmy sperm whale, struvite, urethrolith, urinary calculi.

Reports of calculi of the urogenital system of cetaceans have been uncommon. Renal calculi of unidentified composition were reported as incidental findings in bottlenose dolphins (*Tursiops truncatus*) and an unspecified beaked whale (Simpson and Gardner, 1972; Howard, 1983). Obstructive calculi containing high proportions of phosphate with calcium and oxalate have been observed in the ureter of a Pacific white-sided dolphin (*Lagenorhynchus obliquidens*; Cowan et al., 1986). A vaginal calculus presumed to be of urinary origin (vs. fetal bone remnants more frequently reported in odontocetes) and composed of struvite was reported from a bottlenose dolphin (McFee and Osborne, 2004). The most frequently encountered uroliths in captive bottlenose dolphins are uric acid renoliths (Miller, 1994; Reidarson and McBain, 1994; Townsend and Ridgway, 1995). Renoliths presumed to be composed of uric acid have also been reported antemortem in a captive Pacific white-sided dolphin (Boehm et al., 1997). Renoliths in small captive cetaceans can be subclinical or produce hematuria, anorexia, and behavioral signs referable to abdominal pain. Here, we describe massive struvite urolithiasis of the penile urethra of a stranded pygmy sperm whale (*Kogia breviceps*) as the primary debilitating feature discovered during necropsy.

A dead adult male pygmy sperm whale was discovered 1 November 2002 stranded on Topsail Island, North Carolina, USA (34.71989°N, 76.52027°W). It was in good body condition, had some sunburn, had no evidence of antemortem human interactions, and was graded condition code 3 (Geraci and Lounsbury, 1993). The animal was packed in ice and transported to the National Oceanic and Atmospheric Administration Laboratory, Beaufort, North Carolina, USA, for necropsy the following day. The whale was 296 cm long with a 167.5-cm girth at cranial insertion of the dorsal fin; it was too large to weigh with available equipment. Age was estimated to be 14 yr from growth layers counted in decalcified and stained thin sections of teeth (Hohn et al., 1989).

Primary gross findings were limited to the genitourinary, integumentary, and gas-

FIGURE 1. Penis and urethroliths of a mature male pygmy sperm whale (*Kogia breviceps*). The dissected penis tip (asterisk, approximately 4 cm in length) packed with multiple smaller calculi is detached and placed below the main body of the penis. The urethral diverticulum was located just proximal (right) of the exposed major portion of the calculi at the sigmoid flexure, and smaller cylindrical calculi also filled the undissected distal segment of the penis to the left of the major calculi.

trointestinal systems. The urogenital system was completely examined. The kidneys were bilaterally symmetrical, ureters symmetrical and nondilated, and bladder intact and filled with an estimated 200 ml of clear urine. An aggregation of light tan, mildly rough urethral calculi were present distal to the sigmoid flexure extending to the tip of the penis, occupying the urethra for a distance of 43 cm (Fig. 1). One large multinodular stone from the main body of the penis weighed 208 g and was 16 cm long × 3.7 cm diameter at the widest point. Smaller multinodular and single stones of roughly cylindrical to spherical in shape filled the penile urethra distally, and one discoid stone was lodged in the preputial recess. No stones were found proximal to the sigmoid flexure. A diverticulum filled with an estimated 40 ml of dark-tinged watery fluid was present at the sigmoid flexure just proximal to the main urethrolith. Left and right testes were well developed, at 1.49 and 1.47 kg, respectively, and both epididymides and vasa deferentia were dilated and filled with thin white semen. The right pectoral fin had an elliptical healed perforation distally 4.5×3 cm. Cestode cysts were present in dorsal and perineal blubber, nematode cysts were in the mesentery near the stomach, and a large interstitial nematode was in the ventral cervical blubber. Blubber thickness was 3.4 cm dorsally and 2.4 cm laterally at the level of the pectoral fin insertion and 7.2 cm dorsally and 3.5 cm laterally at the level of the cranial insertion of the dorsal fin. There was sand deep in the esophagus. Numerous live anisakid nematodes were found in the first and second chambers of the stomach, without evidence of gastric ulceration or hyperemia, along with fish skull parts and large numbers of squid beaks. Intestinal contents were unusually thick and pasty in the smaller-diameter portion of the small intestine.

A histologic diagnosis of moderate multifocal to coalescing plasmacytic balanitis and penile urethritis was made. The epithelium of the tip of the penis was markedly hyperplastic with deeply arborizing rete pegs and lymphoplasmacytic infiltration at the epidermal-proprial interface extending throughout the dense fibrous stroma and into myofiber bundles. There was hyperplasia of the urethral transitional epithelium with marked proprial infiltration by primarily plasma cells, occasional Mott cells, fewer lymphocytes, and scattered neutrophils. The lumen of the urethra contained basophilic, partially birefringent granular to crystalline material. The urethral diverticulum was similar to the grossly more normal urethral section, but with more pronounced underlying plasma cell infiltration, and multifocal fragmentation and atrophy of skeletal muscle and associated fibrosis.

Other lesions of note, though not considered debilitating, included parasite-associated gastritis and panniculitis from blubber of the ventral cervical region, mild lymphoid depletion of iliac and gastric lymph nodes, and diffuse moderate congestion of the lungs, which likely was agonal. No histologic lesions of consequence were observed in bronchus, spleen, liver, pancreas, adrenal gland, thyroid, diaphragm, esophagus, heart (left and right atria and ventricles, and atrioventricular valve), cervical spinal cord, kidney, epidid-

ymis, pyloric stomach, or intestine (six sections from duodenum to colon).

Stone analysis and bacterial culture from the stone were performed at the Stone Analysis Laboratory, University of California, Davis, California, USA. Stone analysis was performed by optical crystallography and polarized light microscopy and confirmed by infrared spectroscopy (Ruby and Ling, 1986a). Bacterial culture and antimicrobial sensitivity were performed by standard bacteriologic methods (Ruby and Ling, 1986b). Calculi were composed of 100% struvite (magnesium ammonium phosphate, $Mg(NH_4)(PO_4)\cdot 6H_2O$, or the misnomer triple phosphate). In cross section, the calculi had a surface layer of crystals; an outer layer of light tan, granular, unoriented crystals; and a central core of finely granular, light tan, unoriented crystals. Culture yielded moderate numbers of *Klebsiella oxytoca* resistant to oxytetracycline and sensitive to ampicillin, amoxicillin/clavulanic acid, chloramphenicol, cephalexin, enrofloxacin, and trimethoprim/sulfa.

Much of what is known of the biology of pygmy sperm whales has been gleaned from strandings (Leatherwood and Reeves, 1983). They are odontocetes in the family Physeteridae, with a worldwide distribution in temperate, subtropical, and tropical offshore waters. They are among the most commonly stranded cetacean species along the southeastern US, with 446 reported stranded along the Atlantic and Gulf of Mexico coasts between 1978 and 1997 (Scott et al., 2001). Their diet is composed primarily of squid (Leatherwood and Reeves, 1983; Scott et al., 2001).

Uroliths previously reported in odontocetes have been located primarily in the kidneys or ureter, and when composition has been determined, uric acid has been most common (Miller, 1994; Reidarson and McBain, 1994; Townsend and Ridgeway, 1995; Boehm et al., 1997). In contrast, this pygmy sperm whale had a penile urethrolith composed of 100% struvite. Struvite is the most common urolith of dogs, cats, ferrets, mink, and cattle, whereas calcium carbonate predominates in horses, rabbits, and guinea pigs, and various calcium salts are most frequent in sheep, goats, and pigs (Osborne et al., 1989; Hillyer, 1997; Gorham, 1998). Struvite calculi can form in any portion of the urinary tract: kidney, ureter, urinary bladder, or urethra (Osborne et al., 1986). In dogs, nearly all struvite uroliths are infection-induced, primarily by *Staphylococcus* spp., occasionally by *Proteus* spp., and less commonly by other urease-positive bacteria, including *Klebsiella* sp. (Osborne et al., 1986). In cats, by contrast, struvite uroliths are far less commonly associated with urinary tract infections and are considered metabolically induced (Ling et al., 1990). At 14 yr, this pygmy sperm whale would be considered a young adult. Similarly, in male but not female dogs and cats, struvite uroliths are found most commonly in younger animals, although they are found at a wide range of ages (Ling et al., 1990, 1998).

Struvite urolith formation requires urine magnesium ammonium phosphate supersaturation, which is favored by urinary tract infection with urease-positive bacteria, alkaline urine, genetic predisposition, and high-protein diet (Osborne et al., 1986). Urease produced by bacteria hydrolyzes urea to form two molecules of ammonia and a molecule of carbon dioxide. The ammonia molecules react with water to form ammonium and hydroxyl ions, alkalinizing the urine. Struvite precipitation is promoted both by the increased ammonium ion concentration and increased pH (Osborne et al., 1986). Odontocetes normally have acidic urine, typical of carnivores (Medway and Geraci, 1986), so struvite calculi formation would be less likely in the absence of urinary tract infection with urease-positive bacteria.

Given the size of the calculi, the dilatation of the urethra required to accommodate the calculi, the histopathologic evidence of chronic inflammation of the urethra, the generally good body condition of

this animal, and presence of gastrointestinal contents, the whale presumably was functioning reasonably well for the considerable time necessary for stone accretion to such magnitude. Clinical and experimental studies in dogs indicate that, following infection with urease-producing staphylococci, struvite uroliths can form in 2–8 wk (Osborne et al., 1986), which provides a frame of reference for an extreme lower limit of time required for development of this whale's substantial urethrolithiasis. Interestingly, the last two growth layers of dentin were hypermineralized (Hohn, 1980), suggesting the possibility of secondary or primary systemic mineral imbalances for up to 2 yr.

Apart from the subjectively obvious pain induced by large urethral calculi, additional debility could also result from either urine obstruction or, conversely, urinary incontinence. Blockage of urine flow (postrenal azotemia) leads to disturbances in acid-base and electrolyte balance, and uremia with elevated blood urea nitrogen and creatinine (Ross, 1998). Uremia has adverse effects on mentation, and can also result in ulcerative stomatitis and gastritis (Polzin, 1989). Although it appeared that this pygmy sperm whale was not obstructed, because the urinary bladder was intact and only one-third full and there was no fluid in the abdomen to indicate a urinary tract rupture, it is possible that urethrospasm could have prevented urine flow in life, with postmortem relaxation allowing pressure relief and partial drainage of the bladder. The urethral diverticulum located proximal to the calculi, but lacking any calculi itself, suggests that this feature was acquired rather than developmental, and supports the possibility of at least intermittent obstruction. Alternatively, the whale could have been incontinent. The urethra was dramatically distended to accommodate the calculi, and fissures between the calculi appeared sufficient to permit urine flow. In that case, the urethral sphincter may have been nonfunctional, and urine pooling in a never completely voided bladder would have resulted. Hyperammonemic encephalopathy has been reported in a boy with a distended atonic bladder, urinary incontinence, no azotemia, no obstruction, and a urinary tract infection with *K. oxytoca* (Cheang et al. 1998). Although urine could flow freely so that no uremia developed, the bladder was filled with urine and the urease-positive bacteria created an environment high in ammonia and pH that permitted the unionized ammonia to diffuse into the blood stream at high concentrations, causing severe encephalopathy. In this pygmy sperm whale, two sites of potential urine stasis existed: an incompletely voided bladder and the urethral diverticulum, in which similar conditions of high ammonia concentrations and pH could have prevailed.

Unfortunately, neither speculation can be validated. Sand deep in the esophagus suggested that the animal was still living when it stranded, and live gastric nematodes indicated the carcass was reasonably fresh. Still, because of evident initial decomposition and the 24-h delay from carcass recovery to necropsy examination, no attempt was made to collect blood, and the possibility of collecting aqueous humor was overlooked. The penile urethral calculi were discovered at the end of what, up to then, had been an uneventful necropsy procedure, at which point the urinary bladder and urine were nonrecoverable. Therefore no data are available regarding urine or serum chemistry.

We report finding large struvite urethroliths in a pygmy sperm whale, which represented the major pathologic feature evident from gross and microscopic examination. Whether the urethrolith was the primary cause of stranding cannot be determined, but direct debility from pain and secondary debility from potential metabolic disturbances would have compounded any other adverse condition not detected in our examination. This case illustrates the potential for urinary tract disorders to affect wild cetaceans, and the im-

portance of examining the lower urinary tract during routine necropsies.

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LITERATURE CITED

BOEHM, J. R., M. G. GREENWELL, AND F. COE. 1997. Dietary management in the treatment of uric acid urolithiasis in a Pacific white-sided dolphin (*Lagenorhynchus obliquidens*). Proceedings of the International Association of Aquatic Animal Medicine 28: 134–135.

CHEANG, H.-K., L. RANGECROFT, N. D. PLANT, AND A. A. M. MORRIS. 1998. Hyperammonaemia due to *Klebsiella* infection in a neuropathic bladder. Pediatric Nephrology 12: 658–659.

COWAN, D. F., W. A. WALKER, AND R. L. BROWNWELL, JR. 1986. Pathology of small cetaceans stranded along southern California beaches. *In* Research on dolphins, M. M. Bryden and R. Harrison (eds.). Clarendon Press, Oxford, UK, pp. 323–367.

GERACI, J. R., AND V. J. LOUNSBURY. 1993. Marine mammals ashore: A field guide for strandings, Texas A&M University Sea Grant Publication TAMU-SG-93-601, Galveston, Texas, 305 pp.

GORHAM, J. R. 1998. Mink. *In* The Merck veterinary manual, 8th Edition, S. E. Aiello (ed.). Merck & Co., Whitehouse Station, New Jersey, pp. 1361–1367.

HILLYER, E. V. 1997. Urogenital diseases. *In* Ferrets, rabbits, and rodents: Clinical medicine and surgery, E. V. Hillyer and K. E. Quesenberry (eds.). WB Saunders, Philadelphia, Pennsylvania, pp. 44–52.

HOHN, A. A. 1980. Analysis of growth layers in the teeth of *Tursiops truncatus* using light microscopy, microradiography, and SEM. *In* Age determination of toothed whales and sirenians, W. F. Perrin and A. C. Myrick (eds.). Report to the International Whaling Commission special issue 3, Cambridge, UK, pp. 155–160.

———, M. D. SCOTT, R. W. WELLS, J. SWEENEY, AND A. B. IRVINE. 1989. Growth layers in teeth from free-ranging, known-age bottlenose dolphins. Marine Mammal Science 5: 315–342.

HOWARD, E. B. 1983. Miscellaneous diseases. *In* Pathobiology of marine mammal diseases, Vol. 2, E. B. Howard (ed.). CRC Press, Boca Raton, Florida, pp. 164–225.

LEATHERWOOD, S., AND R. R. REEVES. 1983. Whales and dolphins. Sierra Club Books, San Fransisco, California, pp. 90–93.

LING, G. V., C. E. FRANTI, A. L. RUBY, AND D. L. JOHNSON. 1990. Epizootiologic evaluation and quantitative analysis of urinary calculi from 150 cats. Journal of the American Veterinary Medical Association 196: 1459–1462.

———, ———, ———, ———, AND M. THURMOND. 1998. Urolithiasis in dogs I: Mineral prevalence and interrelations of mineral composition, age and sex. American Journal of Veterinary Research 59: 624–629.

MCFEE, W. E, AND C. A. OSBORNE. 2004. Struvite calculus in the vagina of a bottlenose dolphin (*Tursiops truncatus*). Journal of Wildlife Diseases 40: 125–128.

MEDWAY, W., AND J. R. GERACI. 1986. Clinical pathology of marine mammals. *In* Zoo and wild animal medicine, 2nd Edition, M. E. Fowler (ed.). WB Saunders, Philadelphia, Pennsylvania, pp. 791–797.

MILLER, W. G. 1994. Diagnosis and treatment of uric acid renal stone disease in *Tursiops truncatus.* Proceedings of the International Association of Aquatic Animal Medicine 25: 22.

OSBORNE, C. A., J. S. KLAUSNER, D. J. POLZIN, AND D. P. GRIFFITH. 1986. Etiopathogenesis of canine struvite urolithiasis. Veterinary Clinics of North America: Small Animal Practice 16: 67–86.

———, J. J. SANNA, L. K. UNGER, C. W. CLINTON, AND M. P. DAVENPORT. 1989. Mineral composition of 4500 uroliths from dogs, cats, horses, cattle, sheep, goats, and pigs. Veterinary Medicine 84: 750–764.

POLZIN, D. J. 1989. Spectrum of clinical and laboratory abnormalities in uremia. *In* Current veterinary therapy X: Small animal practice, R. W. Kirk (ed.). WB Saunders, Philadelphia, Pennsylvania, pp. 1133–1138.

REIDARSON, T. H., AND J. MCBAIN. 1994. Ratio of urine levels of uric acid to creatinine as an aid in diagnosis of urate stones in bottlenose dolphins. Proceedings of the International Association of Aquatic Animal Medicine 25: 21.

ROSS, L. A. 1998. Urinary system. *In* The Merck veterinary manual, 8th Edition, S. E. Aiello (ed.). Merck & Co., Whitehouse Station, New Jersey, pp. 1127–1157.

RUBY, A. L., AND G. V. LING. 1986a. Methods of analysis of canine uroliths. Veterinary Clinics of North America: Small Animal Practice 16: 293–301.

———, AND ———. 1986b. Bacterial culture of uroliths: Techniques and interpretation of results. Veterinary Clinics of North America: Small Animal Practice 16: 325–331.

SCOTT, M. D., A. A. HOHN, A. J. WESTGATE, J. R. NICOLAS, B. R. WHITAKER, AND W. B. CAMBELL. 2001. A note on the release and tracking of a rehabilitated pygmy sperm whale (*Kogia breviceps*). Journal of Cetacean Research and Management 3: 87–94.

SIMPSON, J. G., AND M. B. GARDNER. 1972. Comparative microscopic anatomy of selected marine mammals. *In* Mammals of the sea: Biology and medicine, S. H. Ridgway (ed.). Charles C. Thomas Publisher, Springfield, Illinois, pp. 298–418.

TOWNSEND, F. I., AND S. RIDGWAY. 1995. Kidney stones in Atlantic bottlenose dolphins (*Tursiops truncatus*): Composition, diagnosis and therapeutic strategies. Proceedings of the International Association of Aquatic Animal Medicine 26: 2–3.

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