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HEMATOLOGY AND SERUM CHEMISTRY VALUES IN THE BELUGA (*DELPHINAPTERUS LEUCAS*)

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ABSTRACT: Normal values and ranges for 31 clinical hematology and serum chemistry tests are reported for the beluga or white whale (*Delphinapterus leucas*). The values were collected over a 6-yr period from eight belugas maintained for display at Sea World (San Diego, California, USA) facilities and represent long-term evaluations for each animal in a controlled environment. They represent the first report for a number of serum chemistry values for the beluga. Normal values such as these provide an important data base from which to detect diagnostically important changes in health status for belugas in a zoological setting. They also establish a baseline from which to evaluate differences in normal values in free-ranging belugas and from which to diagnose disease problems in wild populations.

Key words: *Delphinapterus leucas*, beluga whale, hematology, serum chemistry, normal values, captive study.

INTRODUCTION

Belugas, or white whales (*Delphinapterus leucas*), have been maintained in oceanaria and aquaria in the United States and Canada since the 1890's (Anonymous, 1903). However, compared with other marine mammal species such as the bottlenose dolphin (*Tursiops truncatus*), the California sea lion (*Zalophus californianus*) and the harbor seal (*Phoca vitulina*), relatively few white whales have been maintained in zoological environments (Cornell and Asper, 1978; Cornell et al., 1982). To date, four white whale calves have been born in these controlled environments.

The long-term maintenance and care of these animals has afforded the opportunity for evaluations of physiological and clinical features in this species (Geraci et al., 1968; Dhindsa et al., 1974; MacNeill, 1975; D'Angelo, 1982; Geraci et al., 1968; Medway and Geraci, 1986). Hematology values have been reported for two belugas maintained by the Vancouver Public Aquarium (MacNeill, 1975) and for 17 belugas from natural populations compared with eight captive belugas (Geraci et al., 1968). Selected clinical chemistry reference values have been given in Medway and Geraci (1986). We present here normal values and ranges for a complete panel of hematology and serum chemistry tests for the beluga. These normal values and ranges are derived from the data in health monitoring records of eight belugas maintained for several years at the three Sea World parks in the United States (San Diego, California; Aurora, Ohio 44202, USA; Orlando, Florida 32821, USA). This summary of values covers 6 yr of data collection from routine blood sampling.

MATERIALS AND METHODS

Eight belugas (five females and three males) were used for this determination of normal clinical values. The site of collection for all eight animals was Churchill, Manitoba, Canada (58°45'N, 94°00'W). Two of the animals were captured between 1973 and 1976; the remainder were collected in 1979. Four of the animals were adults and four were juveniles at the time of capture.

Hematology and serum chemistry data were taken from routine blood sampling records covering a 6-yr period from 1979 to 1985. Blood samples were collected at intervals of approximately 1–2 mo throughout this period. From 40 to 50 data points per animal were used to evaluate normal values for each clinical test.

Blood was collected by venipuncture from the fluke, using a 4 cm (18–20 ga) needle, and placed in EDTA and SST Vacutainer tubes (Becton-Dickinson, Rutherford, New Jersey 07070, USA). Most of the whales were trained to present their flukes for blood sampling and many of the routine samples were obtained in this manner. Blood

TABLE 1. Hematology values for eight captive beluga whales.

Test	Mean	25–75% Range	5–95% Range
Erythrocytes			
Hemoglobin (g/dl)	21	20–22	19–23
Hematocrit (%)	56	53–58	48–62
Red blood cell count ($\times 10^6$/mm^3)	3.26	3.11–3.36	2.90–3.56
Mean corpuscular volume (fl)	171	167–174	161–182
Mean corpuscular hemoglobin (pg)	65	64–66	63–69
Mean corpuscular hemoglobin concentration (g/dl)	38	37–38	35–40
White blood cells			
Total white blood cell count (/mm^3)	8,400	7,600–9,300	7,600–11,000
Differential			
Neutrophils	56[a]	50–61	46–74
	4,700[b]	3,000–5,700	3,500–8,100
Lymphocytes	30	24–34	24–44
	2,500	1,800–3,200	1,900–4,800
Monocytes	6	3–8	2–11
	500	200–700	150–1,200
Eosinophils	8	5–12	2–21
	700	400–1,100	150–2,200

[a] Percent.
[b] Absolute number /mm^3.

was collected, as well, when the pools were lowered for transfer of animals to other areas. At these times, the whales were either placed on foam rubber pads on the bottom of the pool or were held in lifting slings for the sampling. They were kept moist with water spray during this time.

All clinical analyses were performed by the Sea World Laboratory (Sea World, Inc., San Diego, California 92109, USA). Serum was separated by centrifugation within 1 hr of collection. Hematology and serum chemistry values were determined within 24 hr of blood collection. Test procedures have been previously reported (Cornell, 1983). Complete blood counts were performed using a Coulter ZB1, with a Coulter hemoglobinometer (Coulter Electronics, Hialeah, Florida 33014, USA). White blood cell differential counts were done by microscopic examination. Serum chemistry analyses were performed using a Gilford semiautomated chemistry system and Gilford reagents (Gilford Instrument Laboratories, Inc., Oberlin, Ohio 54074, USA). All tests were standardized daily and calibrated for use with marine mammals.

Values for each test were examined by box plot analysis (Chambers et al., 1977). This analysis determined individual animal medians, 25–75% quartiles (the distribution of 50% of the values around this median) and the spread of 90% of the values about the median. Individual medians, quartiles and the 90% limits were averaged for all eight animals for each clinical test to obtain representative normal values and ranges for this group of whales. High, median and low values (high and low values representing the 90% limits from the box plots) were graphed for all animals to look for individual differences in the distribution of the values for any given test. If the high, median and low graphs showed evidence of non-random distribution of these values among the animals, one-way analysis of variance (Zar, 1984) was used to test for age or sex differences.

RESULTS AND DISCUSSION

Normal values are presented in Table 1 (hematology) and Table 2 (serum chemistry). A "narrow" range of normal values is given as the 25% and 75% box plot quartiles averaged over all animals and a "broader" range is described by 90% of the values for all animals.

Hematology

Hemoglobin concentration (Hgb) and hematocrit (Hct) were considerably higher for these eight belugas than for the animals reported by MacNeill (1975) and Geraci

TABLE 2. Serum chemistry values for eight captive beluga whales.

Test	Mean	25–75% Range	5–95% Range
Glucose (mg/dl)	104	94–115	83–134
Serum urea nitrogen (mg/dl)	51	46–57	38–69
Creatinine (mg/dl)	1.4	1.2–1.6	0.9–2.1
Bilirubin total (mg/dl)	0.3	0.2–0.4	0.2–0.6
Cholesterol (mg/dl)	224	194–258	146–314
Triglycerides (mg/dl)	260	205–312	136–360
Total protein (g/dl)	6.9	6.4–7.2	5.9–8.0
Albumin (g/dl)	4.3	4.0–4.6	3.5–5.2
Globulin (g/dl): calc.	2.5	2.1–3.0	1.5–3.8
Amylase (IU/liter)	7	4–11	2–19
Akaline phosphatase (IU/liter)	128	88–163	54–162
Alanine aminotransferase (IU/liter)	12	8–17	3–18
Aspartate aminotransferase (IU/liter)	48	40–60	30–87
Creatine kinase (IU/liter)	85	64–109	30–122
Alpha-hydroxybutyric dehydrogenase (IU/liter)	172	148–203	100–250
Lactic dehydrogenase (IU/liter)	118	101–143	85–200
Calcium (mg/dl)	9.5	9.0–9.9	8.2–10.8
Phosphorus (mg/dl)	5.8	5.4–6.5	4.6–7.4
Chloride (mEq/liter)	109	105–114	97–114
Iron (mcg/dl)	269	202–332	108–415

et al. (1968) (Hgb = 21 g/dl versus 15–18 g/dl; Hct = 56% versus 43–49%). Further investigation may prove these differences to be indicative of hematologic ecotype differentiation in the beluga as has been seen in two other cetacean species, *Tursiops truncatus* (the bottlenose dolphin; Duffield et al., 1983) and *Orcinus orca* (the killer whale; Cornell, 1983). Red blood cell count (RBC) was about the same as in the other beluga studies. Mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH) and mean corpuscular hemoglobin concentration (MCHC) were somewhat different than the other studies relating to the differences seen in Hgb and Hct. They were, in general, quite variable from animal to animal.

Erythrocytes were approximately 8.8 ± 0.4 μm in diameter. Blood smears were routinely examined for abnormal red blood cell morphology. Polychromasia, microcytes, spherocytes, stippling, anisocytosis, poikilocytosis, Howell-Jolly bodies and nucleated red blood cells were seen occasionally. Any consistent increases in these were believed to indicate a change in health status.

No significant differences between males and females or adults and juveniles were seen in total white blood cell counts. The values were at the low end of those previously reported (8,000–12,000/mm^3). Two of the three males examined had normal values which were considerably below those of the other belugas ($\bar{x}$ = 6,300/mm^3 versus the group average of 8,400/mm^3). Age-related differences in total white blood cell count have been recorded in both the bottlenose dolphin and the killer whale (Cornell, 1983; Cornell et al., 1988), with adults having lower white blood cell counts. In the bottlenose dolphin where the juveniles were park-born and -raised, the decrease in white blood cell count seemed to be correlated solely with age. However, in the killer whale a decline in white blood cell count, as well as in eosinophil levels, occurred gradually over time concurrent with the loss of parasites. The differences between the white blood cell values seen here and those previously reported by

MacNeill (1975; 9,000/mm^3) might in part be related to differences in parasite intensities when these animals were taken from the wild populations. White blood cell differential counts were similar to literature values for other belugas. Banded heterophils and basophils were not observed in these data, although low percentages of these cell types were noted by MacNeill (1975).

Serum chemistry

Differences related to sex or age were not seen in glucose, serum urea nitrogen (BUN), creatianine, bilirubin or amylase. The normal ranges for glucose and BUN seen here are in general agreement with other reported values. Cholesterol, triglycerides, total serum protein and albumin showed a trend towards adult versus juvenile differences; the adult values for cholesterol and triglycerides were higher, serum protein and albumin values were lower than for the juveniles.

In general, the values for the clinical enzyme tests were similar between the eight whales and did not show any indication of age or sex differences. However, in the case of alkaline phosphatase (ALP), two of the oldest females had levels of ALP significantly lower than the rest of the animals (medians = 70–80 IU/liter, as compared with 128 IU/liter). Given the relationship of this enzyme to bone metabolism and repair, it would be of diagnostic value to investigate whether a change in ALP levels in older cetaceans is a consistent finding and whether it is related to decreased bone repair.

Calcium, phosphorus and chloride values were lower in this study as compared with literature values, but similar to values reported for other cetacean species (Cornell, 1983; Cornell et al., 1988), as well as for other animals and man (Kaneko, 1980; Byrne et al., 1981).

Throughout the evaluation of these data it was apparent that there were individual differences in the distribution of values for each clinical test. This stresses the importance of routine sampling to establish each individual's normal values over time. Observing a consistent shift in an individual's values over time towards the limits of the narrow, and especially of the broader, range of values indicates a change in health status and facilitates earlier diagnosis and treatment of clinical disease.

Studies of hematology and serum chemistry values in a cetacean maintained in zoological environments in larger numbers, namely in bottlenose dolphin (*Tursiops truncatus*), have allowed statistical detection of both age and sex related differences for normal values of many clinical parameters (Cornell et al., 1988). Although some suggestion of differences by age or sex were seen in the beluga data, a further analysis of these differences must await long-term records from a greater number of belugas.

Hematology and serum chemistry values are among the most commonly used indices in the clinical evaluation of disease, both for animals maintained in a controlled environment and for free-ranging animals. The tests reported here have provided invaluable information for the monitoring of health status in our belugas. As normal values for these clinical tests are largely unknown for wild beluga populations, these normal values from a controlled environment represent a measure from which to compare differences and to evaluate disease in free-ranging belugas.

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LITERATURE CITED

ANONYMOUS. 1903. The beluga or white whale, Sci. *Delphinapterus leucas*. New York Zoological Society Bulletin 9: 81.

BYRNE, C. J., D. F. SAXTON, P. K. PELIKAN, AND P. M. NUGENT. 1981. Laboratory tests: Implica-

tions for nurses and allied health professionals. Addison-Wesley, Menlo Park, California, 384 pp.

CHAMBERS, J. M., W. S. CLEVELAND, B. KLEINER, AND P. A. TUKEY. 1977. Graphical methods for data analysis. Wadsworth International Group, Belmont, California, 275 pp.

CORNELL, L. H. 1983. Hematology and clinical chemistry values in the killer whale, *Orcinus orca* L. Journal of Wildlife Diseases 19: 259–264.

———, AND E. D. ASPER. 1978. A census of captive marine mammals in North America. International Zoo Yearbook 18: 220–224.

———, ———, AND D. A. DUFFIELD. 1982. Census up-date: Captive marine mammals in North America. International Zoo Yearbook 22: 227–232.

———, D. A. DUFFIELD, B. E. JOSEPH, B. STARK, AND C. PERRY. 1988. Hematology and serum chemistry values in bottlenose dolphins. *In* The bottlenose dolphin, S. Leatherwood and R. Reeves (eds.). Harcourt, Brace, Jovanovich, Orlando, Florida, In press.

D'ANGELO, G. 1982. Evidence for an erythrocyte glucose transport system in the beluga whale, *Delphinapterus leucas*. Cetology 42: 1–9.

DHINDSA, D. S., J. METCALFE, A. S. HOVERSLAND, AND R. A. HARTMAN. 1974. Comparative studies of the respiratory functions of mammalian blood. X. Killer whale (*Orcinus orca* Linnaeus) and beluga whale (*Delphinapterus leucas*). Respiratory Physiology 20: 93–103.

DUFFIELD, D. A., S. H. RIDGWAY, AND L. H. CORNELL. 1983. Hematology distinguishes coastal and offshore forms of dolphins (*Tursiops*). Canadian Journal of Zoology 61: 930–933.

GERACI, J. R., W. MEDWAY, H. FINK, AND B. BECK. 1968. Studies on the hematology of the beluga whale *Delphinapterus leucas* (Pallaf). *In* Proceedings of the Second Symposium on Diseases and Husbandry of Aquatic Mammals. Florida Atlantic University Press, Boca Raton, Florida, pp. 63–74.

KANEKO, J. J. 1980. Clinical biochemistry of domestic animals. Academic Press, San Francisco, California, 832 pp.

MACNEILL, A. C. 1975. Blood values for some captive cetaceans. Canadian Veterinary Journal 16: 187–193.

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

RIDGWAY, S. H., C. A. BOWERS, D. MILLER, M. L. SCHULTZ, C. A. JACOBS, AND C. A. DOOLEY. 1984. Diving and blood oxygen in the white whale. Canadian Journal of Zoology 62: 2349–2351.

ZAR, J. H. 1984. Biostatistical analysis. Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 680 pp.

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