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SERUM CHEMISTRY OF BOWHEAD WHALES (*BALAENA MYSTICETUS*)

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ABSTRACT: Sera of 19 male and female bowhead whales (*Balaena mysticetus*) collected near Barrow, Alaska (USA) between 30 August and 13 October 1992 were evaluated for 18 serum chemistry values. Male bowhead whales had significantly greater creatinine and sodium concentrations, and significantly lower glucose concentrations than females. Pregnant females had greater triglyceride levels than non-pregnant females. The mean concentrations of creatinine, blood urea nitrogen, alkaline phosphatase, total bilirubin, total protein, sodium, potassium, chloride, phosphorus, and calcium were similar to those previously reported from bowhead whales. High aspartate aminotransferase and creatine kinase levels were attributed to muscle damage associated with harpooning.

Key words: Serum, chemistry, bowhead whale, cetacean, *Balaena mysticetus*.

INTRODUCTION

Serum chemistry is a useful diagnostic tool for monitoring the health of marine mammals. The levels of some serum constituents have been determined for captive cetaceans (Medway and Moldovan, 1966; Cornell, 1983; Bossart and Dierauf, 1990), but only limited measurements of these factors have been conducted in the larger, free-ranging whales (Medway, 1983; Lambertsen et al., 1986). By necessity, these latter studies have been based upon analysis of serum collected from recently killed whales.

The bowhead whale (*Balaena mysticetus*) is a large (up to 16 m), ice-associated, baleen whale of northern waters. Limited numbers of the animals are taken by Eskimo hunters of northern and northwestern Alaska (USA), with the subsistence harvest quota set by the International Whaling Commission (Tillman, 1980). The largest stock of bowhead whales uses the Bering, Chukchi, and Beaufort Seas (Zeh et al., 1993). Through the cooperation of the Eskimo hunters, tissue and fluid specimens from killed whales have supported a wide range of studies, including morphological studies. We report here the results of an extensive analysis of serum chemical constituents of the bowhead whale, in order to better evaluate disease processes in these animals which play a major role in the culture and nutrition of the Eskimo people.

MATERIALS AND METHODS

Twenty mature bowhead whales were killed by Eskimo subsistence hunters using hand-thrown harpoons with attached explosive projectiles, near Barrow, Alaska (71°17′N, 156°45′W) between 30 August and 13 October 1992. The whales were 7.5 m to 16.2 m long, and included 12 females (three pregnant) and eight males. The whales were pulled onto land to be butchered for food. During this process, each whale was carefully examined for evidence of gross tissue lesions, and blood was collected. Ten of the blood samples were taken from an incision across the anterior aspect of the hard palate. In the other cases, blood was taken at various sites (fluke, thorax, peduncle) from incisions in the musculature. Sampling sites were dry and clean, and 90 to 120 ml of freely-flowing whole blood were collected directly into sterile 8 to 15 ml polypropylene or polystyrene plastic screw-top tubes, and temporarily stored at approximately 4 C until prepared for long-term storage. The tubes later were centrifuged, and the sera were removed, frozen, and transported to the Veterinary Diagnostic Laboratory, College of Veterinary Medicine, Oregon State University, Corvallis, Oregon (USA) for analysis. Estimated time from death to blood collection was 4 to 12 hr,

TABLE 1. Serum chemistry of 19 bowhead whales (*Balaena mysticetus*) from Barrow, Alaska, August to October 1992.

	Pregnant females (n = 3)		Non-pregnant females (n = 8)	
Total length (m)	15.0 ± 0.8	(14.2–15.7)[a,b]	11.7 ± 3.2	(7.5–16.2)
Blood urea nitrogen (mg/dl)	73.7 ± 6.9	(66.2–79.9)	66.1 ± 6.0	(60.4–78.5)
Creatinine (mg/dl)	4.3 ± 2.3	(2.8–7.0)	3.6 ± 1.1	(2.5–5.2)
Glucose (mg/dl)	93.7 ± 14.6	(78–107)	98.8 ± 18.5	(62–116)
Total protein (g/dl)	9.5 ± 1.7	(7.8–11.1)[b]	7.1 ± 0.6	(6.4–7.6)
Albumin (g/dl)	5.4 ± 0.2	(5.3–5.7)[b]	4.6 ± 0.5	(3.6–5.2)
Total bilirubin (mg/dl)	1.0 ± 0.7	(0.5–1.8)	0.8 ± 0.3	(0.3–1.2)
Alkaline phosphatase (IU/l)	175.7 ± 75.2	(94–242)	313.8 ± 176.5	(99–649)
Creatine kinase (IU/l)	2,522.7 ± 1,333.7	(1,016–3,552)	2,046.4 ± 1,479.5	(113–4,544)
Gamma glutamyl transferase (IU/l)	11.3 ± 5.7	(5–16)	5.8 ± 4.7	(1–14)
Aspartate aminotransferase (IU/l)	198.3 ± 142.9	(73–354)	255.6 ± 228.2	(41–486)
Sodium (mEq/l)	180.0 ± 5.2	(174–183)	179.1 ± 9.3	(162.0–188.0)
Potassium (mEq/l)	8.7 ± 1.4	(7.2–9.9)	9.8 ± 2.8	(6.9–14.9)
Chloride (mEq/l)	126.7 ± 0.6	(126–127)	122.5 ± 9.1	(107–133)
Calcium (mEq/l)	12.0 ± 1.0	(10.8–12.6)	11.2 ± 1.4	(8.7–12.8)
Phosphorus (mEq/l)	12.1 ± 3.8	(7.8–14.4)	10.2 ± 1.9	(7.6–12.8)
Cholesterol (mg/dl)	488.0 ± 162.0	(347–665)	392.8 ± 82.7	(285–559)
Triglycerides (mg/dl)	485.0 ± 246.8	(200–628)[b]	271.1 ± 60.8	(186–362)
Uric acid (mg/dl)	5.9 ± 3.7	(1.6–8.3)	4.8 ± 2.3	(1.3–7.2)

[a] Mean ± standard deviation (range).
[b] Significant difference between pregnant and non-pregnant females ($P < 0.05$).
[c] Significant difference between females and males ($P < 0.05$).

but usually was 6 to 8 hr for whales greater than 13 m long and 4 to 5 hr for those less than 13 m long. Estimated time from collection of blood to separation of serum ranged from 4 to 8 hr.

The serum chemistries were determined using an automated random access analyzer, Model 550 Express (Ciba Corning, Oberlin, Ohio, USA), and electrolyte concentrations were determined using a direct potentiometric ion-selective analyzer, 664 Fast 4 System (Ciba Corning). The following constituents were measured: blood urea nitrogen (BUN), creatinine, glucose, total protein, albumin, total bilirubin, alkaline phosphatase (ALP), creatine kinase (CK), gamma glutamyl transferase (GGT), aspartate aminotransferase (AST), cholesterol, triglycerides, uric acid, calcium, phosphorus, sodium, potassium, and chloride.

Statistical analysis was by Student's t-test (Quattro Pro for Windows, Version 6.0, Borland, Scotts Valley, California, USA), with $P < 0.05$ considered to be statistically significant.

All samples were collected under Permit No. 519 issued to Dr. T. F. Albert by the U.S. National Marine Fisheries Service.

RESULTS

Sera from 19 animals were suitable for analysis; one serum sample was not used due to severe hemolysis. Hemolysis in the other samples ranged from none to slight as assessed by visual inspection. No gross lesions were detected in organ systems.

Significant differences in the levels of some serum constituents were present within this group of 19 whales (Table 1). The levels of creatinine and sodium were higher and glucose lower in males than in females, and pregnant females had higher levels of total protein, albumin, and triglycerides than non-pregnant females. The six smaller whales (<11 m), had significantly greater mean (+ SD) ALP (440.5 ± 118.57 IU/l and calcium (12.36 ± 0.85 mEq/l) than the 13 larger whales (198.15 ± 112.87 IU/l and 10.73 ± 1.88 mEq/l, respectively). Wide reference ranges were observed for BUN, creatinine, glucose, ALP, CK, AST, potassium, and triglycerides.

DISCUSSION

Sex-related differences in creatinine, sodium, and glucose have not been reported

TABLE 1. Extended.

All females (n = 11)		Males (n = 8)		Total (n = 19)	
12.8 ± 3.0	(7.5–16.2)	12.4 ± 2.4	(8.8–15.0)	12.6 ± 2.7	(7.5–16.2)
68.2 ± 6.9	(60.4–79.9)	61.4 ± 16.7	(21.2–73.4)	65.3 ± 12.1	(21.2–79.9)
3.8 ± 1.4	(2.5–7.0)[c]	5.7 ± 2.1	(2.3–8.1)	4.6 ± 1.9	(2.3–8.1)
97.4 ± 17.0	(64–116)[c]	72.4 ± 29.9	(9–109)	86.8 ± 25.9	(9–116)
7.8 ± 1.4	(6.4–11.1)	7.8 ± 1.2	(6.2–9.7)	7.8 ± 1.3	(6.2–11.1)
4.8 ± 0.6	(3.6–5.7)	4.9 ± 0.4	(4.5–5.5)	4.8 ± 0.5	(3.6–5.7)
0.9 ± 0.4	(0.03–1.8)	0.6 ± 0.3	(0.3–1.0)	0.7 ± 0.4	(0.3–1.8)
276.1 ± 164.6	(94–693)	272.8 ± 207.3	(61–693)	274.7 ± 178.2	(61–693)
2,176.3 ± 1,392.0	(113–4,544)	1,151.0 ± 929.1	(157–2,291)	1,744.6 ± 1,297.1	(113–4,544)
7.3 ± 5.4	(1–16)	6.3 ± 4.3	(2–15)	6.8 ± 4.8	(1–16)
240.0 ± 203.1	(112–680)	173.9 ± 192.0	(36–482)	212.2 ± 195.9	(41–680)
179.4 ± 8.1	(162–188)[c]	189.9 ± 6.1	(179–198)	183.8 ± 8.9	(162–198)
9.5 ± 2.5	(6.9–14.9)	9.0 ± 1.4	(6.8–11.0)	9.3 ± 2.0	(6.8–14.9)
123.6 ± 7.8	(107–133)	129.6 ± 4.5	(125–137)	126.2 ± 7.2	(107–137)
11.4 ± 1.3	(8.7–12.7)	11.0 ± 2.4	(5.7–13.1)	11.3 ± 1.8	(5.7–13.1)
10.7 ± 2.5	(7.6–14.4)	10.1 ± 1.4	(7.8–11.9)	10.4 ± 2.1	(7.6–14.4)
418.7 ± 109.6	(285–665)	397.3 ± 40.9	(352–442)	409.7 ± 86.3	(285–665)
329.5 ± 157.3	(186–628)	228.6 ± 88.6	(166–425)	287.0 ± 139.4	(166–628)
5.1 ± 2.6	(1.3–8.3)	3.1 ± 1.8	(1.6–6.8)	4.3 ± 2.5	(1.3–8.3)

previously, and these findings may relate to individual variability. Decreased plasma protein is often observed during pregnancy in many species (Benjamin, 1978). However, the pregnant whales had significantly greater total protein, albumin, and triglycerides compared to nonpregnant females (Table 1). The site at which blood was collected was not associated with significant differences in serum parameters (data not shown).

The mean and range of creatinine, BUN, ALP, total bilirubin, total protein, sodium, potassium, chloride, phosphorus, and calcium in these whales were similar to those found in six bowhead whales by Medway (1983). Those animals were from the same geographic area and killed in the same manner as in the current study. The serum chemistry values of free-ranging fin whales (*Balaenoptera physalus*) (Lambertsen et al., 1986), and captive killer whales (*Orcinus orca* L.) (Cornell, 1983), beluga whales (*Delphinapterus leucas*) (Cornell et al., 1988), and pilot whales (*Globicephala malaena*) (Medway and Moldovan, 1966) can also be compared to the bowhead whale values in the present study.

While the average and range of serum ALP in bowhead whales was similar in this study and that conducted by Medway (1983), average bowhead ALP exceeded that of the killer, beluga, or pilot whales. Increased ALP is associated with a variety of physiologic and pathologic processes, such as increased osteoblastic activity in young animals, pregnancy, liver disease, and hyperadrenocorticism (Benjamin, 1978). The greater ALP and calcium levels in the small whales may be due to bone growth and remodeling in presumably younger animals (Coles, 1986). Elevations of ALP have been associated with holding sera at room temperature (Benjamin, 1978), which did not occur in the present study.

A wide range of glucose concentrations was found not only in the bowhead whales, but also in the killer and beluga whales. Glucose levels can be diminished as much as 7 to 10% per hour while erythrocytes are in contact with serum (Duncan and

Prasse, 1986). Also, glucose and triglycerides vary inversely with the duration of the postprandial period.

The average AST and CK in our study were high and it seems likely that they reflect abnormalities. Elevated CK and AST can be attributed to muscle damage in marine mammals (Bossart and Dierauf, 1990), and as the whales were killed using explosive devices, it is reasonable to expect that the associated muscle damage would lead to elevation of CK and AST. Bowhead AST and CK levels were high compared to captive, non-traumatized killer, beluga, and pilot whales. Increased AST can be caused by liver disease (Bossart and Dierauf, 1990); while not unequivocal evidence of normal hepatic function, total bilirubin in these whales was low.

Sodium and potassium levels were similar in the present and previous bowhead studies, and were greater than those found in the fin, killer, beluga, or pilot whales. If this reflects an elevation above normal values for the bowhead, certain precipitating factors should be considered. Massive cellular necrosis (Duncan and Prasse, 1986) and shock with subsequent acidosis (Benjamin, 1978) may have contributed to the elevation of potassium. Again, the manner by which the bowhead whales were killed should be considered when evaluating potassium. We attempted to minimize spurious increases of serum potassium due to hemolyzed or clotted blood (Bossart and Dierauf, 1990) as much as field conditions would allow. Artifactual elevation of sodium due to sea water contamination (Lambertsen et al., 1986) was unlikely, as our samples were collected from dry, clean sites during land butchering of the whales.

Phosphorus, calcium, and chloride levels in the bowhead studies were similar to those measured in the fin whales, and were higher than those observed in the captive toothed whales. In the absence of an artifactual increase of phosphorus due to hemolysis, it would seem likely that these values are representative of the normal condition. Chloride levels tend to mimic those of sodium, due to the gradient caused by the sodium pump (Bossart and Dierauf, 1990).

The BUN of the bowhead whales was similar to that of the fin and pilot whales but was greater than the killer and beluga whales, and average bowhead creatinine was greater than that of the fin whale, killer, or beluga whales. While the values may be indicative of the normal state, the possibility of underlying causes for an increased BUN and creatinine should be considered. In the absence of renal lesions, the potential for prerenal azotemia secondary to hypovolemic shock (Benjamin, 1978) should be considered as a possible source of elevated BUN and creatinine in harpooned whales.

Hemolysis can influence the measurement and interpretation of serum constituents. Hemolysis within cetacean samples can cause artifactual elevations in potassium, creatinine, AST, and phosphorus, and false depressions of sodium, but these alterations were described as small and likely insignificant, even when hemolysis was moderate (Lambertsen et al., 1986). Hemolysis can cause alterations in the levels of certain serum constituents in the horse (Dorner et al., 1981). Elevated creatinine, alanine aminotransferase, and total bilirubin, and diminished sodium were characteristic of sera to which 92 to 194 mg/dl of hemoglobin were added. In that study, up to 194 mg/dl of hemoglobin had only a slight and insignificant relationship with total protein, phosphorus, ALP, calcium, BUN, glucose, potassium, chloride, AST, cholesterol, and albumin. We detected severe hemolysis in only one sample and it was not analyzed; all other samples had little to no visible hemolysis. The sodium levels in all of the samples were high, confirming a lack of dilution of this electrolyte by red cell lysis (Lambertsen et al., 1986).

The serum chemistry profile of the bowhead whale was characterized. Correlations of these values with lesions will make this information a useful clinical tool. The low standard deviations and similar refer-

ence ranges of many of the parameters, and their similarity to those reported by others, together with the absence of gross lesions, is evidence that these values are representative. However, the potential influence of stress and muscle trauma must be considered when evaluating the serum chemistry of harpooned animals.

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