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NOTE

Hepatic lipomas and myelolipomas in subsistence-harvested bowhead whales *Balaena mysticetus*, Alaska (USA): a case review 1980–2016

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ABSTRACT: We describe a case series of benign hepatic fatty tumors in 10 subsistence-harvested bowhead whales. Microscopic features included lipomatous and myelolipomatous masses. Extensive atrophy and/or destruction of hepatic parenchyma was not observed. No other significant disease was present except in an animal with unrelated chronic pleuritis. Based on our longitudinal case series (1980–2016) which identified 1–2 hepatic lipomas and myelolipomas in landed whales annually at Barrow, Alaska (USA), since 2012, hepatic lipomas and myelolipomas are occasionally seen in hunter-harvested bowhead whales. A conservative estimate for the percentage of bowhead whales with hepatic fatty tumors in landed whales in Barrow from 2012 to 2016 was 6% (7/111). The pathogenesis and exact cell origin of these benign fatty tumors in bowhead whales is undetermined. Assessment of further cases is warranted to better define the tissue distribution and pathogenesis of these tumors in bowhead whale liver.

KEY WORDS: Aboriginal whaling · Alaska · *Balaena mysticetus* · Bowhead whale · Hepatic lipoma · Hepatic myelolipoma

INTRODUCTION

Bowhead whales *Balaena mysticetus* are central to Alaskan Eskimo culture and an important subsistence resource. Aboriginal bowhead whale hunting occurs during the spring and fall in 11 Alaskan whaling communities and has been regulated by a quota system under the authority of the International Whaling Commission (IWC) since 1977. In cooperation with the Alaska Eskimo Whaling Commission (AEWC) and whaling captains, over 1000 subsistence harvested bowhead whales since the mid-1970s have been regularly inspected by post mortem evaluation by hunters, whale biologists, and veterinarians to assess the health status of the landed whales and to collect tissue specimens and baseline data on life history, natural diseases, and marine threats (i.e. line entanglement, ship strike, oil exposure; Philo et al. 1993, Stimmelmayr 2015, Von Duyke et al. 2016, George et al. 2017).

Here we report the incidence, sex and age distribution, and gross and histopathological characteristics of benign fatty tumors in the liver of 10 bowhead whales harvested between 1980 and 2016 in Barrow (71.29° N, 156.79° W) and Kaktovik (70.13° N, 143.62° W), Alaska, USA.

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MATERIALS AND METHODS

Ten individual harvested whales were sexed and aged based on a combination of published criteria (i.e. genital groove length, total body length; George et al. 1999). Whales were examined within 5–10 h of death, and carcass condition was classified as described by Geraci & Lounsbury (1993). Examination of whales and their visceral organs followed a standard large cetacean necropsy protocol (McLellan et al. 2004). The protocol was modified to align with the traditional utilization of bowhead whales for consumption (Carroll 1976) and the Inupiaq bowhead whale butchering process, whereby chest and abdominal organs are removed together. Completeness of viscera examination was consistent among the examined whales landed in Barrow from 2012 to 2016.

RESULTS

Total body length of bowhead whales with fatty lesions ranged between 8.4 and 12.8 m, with a median of 8.7 m. Sex and age class distribution was 4 immature males and 6 immature females (Table 1). Macroscopic lesions consisted of well-demarcated random white to yellow to pink-white single or multiple nodules/masses on the diaphragmatic surface of the bi-lobed liver (Fig. 1). On cut surface, the nodules extended into the liver parenchyma. Lesion texture was soft with the exception of 4 masses being gritty on cross section. The lesions ranged from 0.5–3.0 cm in diameter. Tissue samples of liver lesions were fixed in 10% buffered formalin, routinely processed, sectioned at 5 µm, and stained with hematoxylin and eosin (H&E). Other organs routinely collected included lung, lymphoid (spleen and/or lymph node), gonads, kidney, heart, and skin.

Fig. 1. Macroscopic image of multiple lipomatous lesions in the liver of an immature female bowhead whale *Balaena mysticetus* (ID no. 13B12) from Barrow, Alaska, USA. The cream-colored, raised, irregularly shaped mass was 3 × 3 cm and extended about 2 cm into the liver. Scale bar is in cm

Fatty lesion morphology was lipomatous and myelolipomatous (Fig. 2). Histopathologic findings common to all cases was the presence of a well-demarcated, unencapsulated neoplasm composed of sheets and nests of variably sized mature adipocytes with thin cell membranes and abundant clear cytoplasm, supported by a fine fibrovascular stroma. In the myelolipomas (5/10), in addition to the adipocytes, bone (5/10) and/or myeloid elements (2/10) were present (Table 2). Regardless of histopathologic variation, adjacent hepatocytes were either compressed or effaced. With the exception of one whale that had an unrelated chronic granulomatous pleuritis of an unknown etiology, no lesions in other organ systems were present in the examined whales.

Table 1. Gross pathology, sex, and age of 10 immature bowhead whales *Balaena mysticetus* with lipomatous lesions of the liver. Animals were harvested in Barrow and Kaktovik, Alaska, USA, between 1980 and 2016. All lipomatous masses were found on the diaphragmatic aspect of the liver

ID	Sex	No. of lesions	Size (cm)	Color	Contour	Histologic type
80B2[a]	M	Single	2.5 × 1.5	Pink-white	Raised	Lipomatous
03B11	F	Single	2 × 3	Cream	Flat	Lipomatous
12B4	F	Single	2 × 2	Cream/yellow	Raised	Myelolipomatous
13B12	F	Multiple/clustered	1–2.5	Cream/pink	Raised/embedded	Myelolipomatous
13B21[b]	F	Single	0.5–1	White	Raised	Lipomatous
14B1	M	Multiple/clustered	0.5–1	Pink-white	Raised/embedded	Lipomatous
14B8	F	Multiple/clustered	2–3	Pink-white	Raised/embedded	Myelolipomatous
15KK1	M	Single	3 × 3	Cream/yellow	Raised	Myelolipomatous
15B14	M	Single	1 × 1	Pink-white	Raised	Myelolipomatous
16B7	F	Single	0.5 × 0.5	Pink-white	Embedded	Lipomatous

[a]Previously published case (80B2); Migaki & Albert (1982)
[b]Only gross examination; no tissues collected

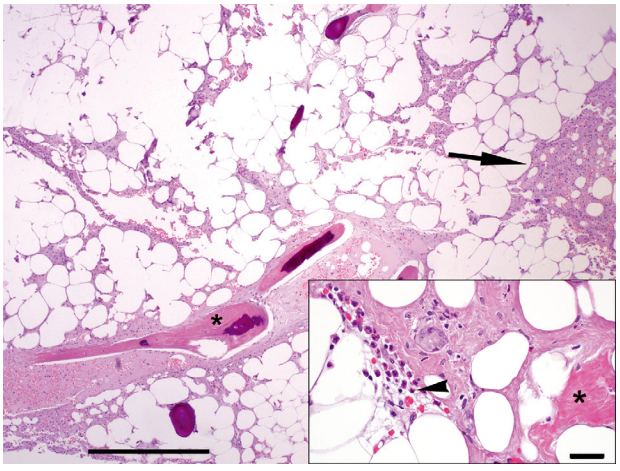

Fig. 2. Histopathologic image of a myelolipoma in the liver of an immature female bowhead whale *Balaena mysticetus* (ID no. 13B12). Well-differentiated plump adipocytes and bony trabeculae (asterisk) replace normal hepatic architecture and compress remaining hepatocytes (arrow). Scale bar = 200 µm. Inset shows detail of adipocytes, bone (asterisk), and hematopoietic components (arrowhead). Scale bar = 20 µm. Hematoxylin and eosin stain

Table 2. Histologic component of the lipomatous hepatic masses of 10 immature bowhead whales *Balaena mysticetus*. All masses were composed of mature adipocytes, with fewer containing myeloid elements and bone

ID	Adipocytes	Myeloid	Bone
80B2[a]	Y	N	N
03B11	Y	N	N
12B4	Y	Y	Y
13B12	Y	Y	Y
13B21[b]	Y	N	N
14B1	Y	N	N
14B8	Y	N	Y
15KK1	Y	N	Y
15B14	Y	N	Y
16B7	Y	N	N

[a]Previously published case (80B2); Migaki & Albert (1982)
[b]Only gross examination; no tissues collected

DISCUSSION AND CONCLUSIONS

Incidental solitary and/or multiple lipomas with or without bone, and or bone marrow components have frequently been described in a variety of avian and mammalian species, including humans (Young 1951, Lombard et al. 1968, Stroud et al. 1982, Dixon et al. 1994, Latimer & Rakich 1995, Zhuo et al. 1995, Klopfleisch et al. 2009, Suzuki et al. 2010, Kleinschmidt et al. 2015). Lipomatous masses include myelolipomas, lipomas, angiomyelolipomas, and mature teratomas; we found no histopathologic evidence of the latter 2 types of lesions in the examined case material. Various etiological hypotheses have been proposed, including endocrine–metabolic disturbance (lipomas), extra-medullary hematopoiesis (myelolipomas), embolization and ectopic tissue, and chronic environmental stimulus resulting in metaplasia of stem cells (Stroud et al. 1982, Dixon et al. 1994, Martin-Benitez et al. 2012). The pathogenesis and exact cell origin of these benign fatty tumors in bowhead whales is undetermined. The presence of 2 microscopic types could represent separate causal factors; however, given that both have been observed with the same frequency (lipomatous: 5/10; myelolipomatous: 5/10) and that the presence of bone and hematopoietic elements was always contained within the lipomatous masses, these tumors likely have a shared cause(s) and could represent a continuum from solely adipocytes to adipocytes with myeloid and osseous elements. This pattern in tissue differentiation could be caused, for instance, by differences in local oxygen tensions, since stem cells can differentiate into fibroblasts or osteoblasts depending on whether the microenvironment is low or high in oxygen, respectively (Mohyeldin et al. 2010).

Based on our longitudinal case series (1980–2016), hepatic lipomas and myelolipomas are not uncommon in bowhead whales, with 1–2 fatty lesions of the liver detected annually in landed whales at Barrow, Alaska, since 2012. Single case reports of lipomas of the liver and the brain have been previously documented in 2 baleen whale species, i.e. bowheads and humpback whales *Megaptera novaeangliae*, but not in toothed whales (Pilleri 1966, Migaki & Albert 1982). Reports of other neoplasms of the liver in cetaceans are equally rare despite a continued expansion of the literature (Newman & Smith 2006). Of the hepatic tumors reported, hepatocellular carcinomas have been reported in beluga whales in the Saint Lawrence estuary (Martineau et al. 2002). There is an epidemiological link to hepatocellular carcinoma and other cancers in beluga whales with exposure to polycyclic aromatic hydrocarbons. A realistic estimate of prevalence for this type of hepatic lesion in bowhead whales is difficult to assess. Completeness of viscera examination during the spring (April–May) and fall (September–October) bowhead whale hunt is often challenging under the extreme arctic field conditions (e.g. limited daylight during fall, inclement weather, low temperatures). In addition, the enormous size and weight of viscera, small size of hepatic lesions, and prosector experience also influence the post mortem examination (Migaki & Albert 1982, Philo et

al. 1993). A conservative estimate for the percentage of bowhead whales with hepatic fatty tumors in landed and examined whales in Barrow from 2012 to 2016 is 6% (7/111). The biological behavior of these hepatic lipomatous and myelolipomatous lesions is not known, but histologic features suggest that these are benign proliferative lesions. Additionally, these lesions are not associated with extensive atrophy and/or destruction of hepatic parenchyma. No other common histopathologic findings were observed in the animals.

In conclusion, our case series presents novel gross and histopathological findings, sex, and age distribution of benign fatty tumors in large baleen whales and contributes to the general knowledge of natural disease conditions in bowhead whales. Assessment of further cases is warranted to better understand the pathogenesis of benign fatty tumors of the liver in bowhead whales.

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