Case report

Seal and whale meat: two newly recognized food allergies

Laura M. Moore, MD*; Melinda McNeal Rathkopf, MDP‡; Carol J. Sanner, MS†; Bonnie A. Whisman, MS*; and Jeffrey G. Demain, MD‡

Background: Alaska's marine mammals compose a large portion of the diet of indigenous coastal Alaskan people. Bowhead whales (*Balaena mysticetus*) and bearded seals (*Erignathus barbatus*), inhabitants of the Bering and Beaufort seas along Alaska's western and northern coasts, are 2 of the most important subsistence species, serving as major food sources to the native population.

Objective: To describe an Inupiaq boy with symptoms consistent with an IgE-mediated food allergy after ingestion of bowhead whale and bearded seal meat.

Methods: Extracts of cooked bowhead whale and bearded seal were prepared, lyophilized, and evaluated for protein content. Sodium dodecyl sulfate–polyacrylamide gel electrophoresis was performed for each extract, followed by transfer to nitrocellulose and IgE immunoblots. Skin prick testing was conducted using reconstituted extracts of 1:10 wt/vol dilution.

Results: Immunoblots revealed serum specific IgE binding with the extracts of bowhead whale and bearded seal meat. Protein bands of approximately 25, 40, 50, and 90 kDa were found in the seal meat. Protein bands of 55 and 90 kDa were found in the whale meat. Skin prick test results were positive to whale and seal extracts with appropriate positive and negative controls. Ten control subjects had negative reactions to both extracts.

Conclusion: A patient with moderate anaphylaxis to bowhead whale and bearded seal meat demonstrated serum specific IgE by means of immunoblot and positive skin prick test results. This is the first known reported case of specific IgE to these species.

Ann Allergy Asthma Immunol. 2007;98:92–96.

INTRODUCTION

Food allergy occurs in up to 6% of children and 3.5% of adults,[1] with the most common foods implicated in children being cow's milk, egg, wheat, and soy. However, because approximately 85% of children outgrow their food allergies by 5 years of age, adults tend more often to be allergic to peanuts, tree nuts, fish, and shellfish, with only the more severe allergies persisting into adulthood.[1] Avoidance remains the treatment of choice until lack of specific IgE can be documented via skin prick testing (SPT) or radioallergosorbent testing. We describe a patient with moderate anaphylaxis after ingestion of bowhead whale and bearded seal meat, 2 previously unreported food allergens. Because of the important dietary role of these meats for thousands of Alaskan natives, the medical consequences of their consumption merits further research.

* Wilford Hall Medical Center, Lackland AFB, Texas.
† Alaska Department of Transportation and Public Facilities, Anchorage, Alaska.
‡ Allergy, Asthma, and Immunology Center of Alaska LLC, Anchorage, Alaska.
The views expressed in this article are those of the authors and do not represent the official policy or position of the US Air Force, the Department of Defense, or the US government.
Received for publication February 28, 2006.
Accepted for publication in revised form June 14, 2006.

Marine mammals compose 14% of Alaska's subsistence diet of plants and animals, with whales and seals being the primary marine mammals sought for food by Alaskan native people.[2] Bowhead whales and bearded seals are 2 of the most important species sought by indigenous Alaskans. The bowhead whale (*Balaena mysticetus*), although listed as an endangered species, is harvested in Alaska by 10 Inupiaq and Yupik Eskimo villages under special management arrangements between the International Whaling Commission, the National Oceanic and Atmospheric Administration Fisheries, and the Alaskan Eskimo Whaling Commission.[3] Once captured, whales are hauled onto the ice, butchered, and distributed in a ritual in which the entire village partakes. Every part of the whale is used for food and implements or is fashioned into artwork. The bowhead whale is a staple traditional food that supports a population of more than 10,000 coastal Alaskans.[4] The bearded seal (*Erignathus barbatus*), so named for its white whiskers, is the largest of the true seal family found in Alaska. Although there are 4 other true seal species hunted in this range, the bearded seal, known locally as *oogruk*, is considered to have the best meat and the most blubber because of its size, reaching more than 750 lb. Its hide is especially sought after for *mukluk* boot soles, rawhide rope, and durable rifle cases. Because up to 92% of households in this region consume bearded seal, it is believed that this

marine mammal is important to a population of more than 20,000 Alaskan natives.[5]

CASE REPORT

The patient was first seen at 11 months of age with complaints of chronic cough and atopic dermatitis (AD) since 3 months of age; urticaria after the ingestion of milk, cheese, and dried whale meat; and urticaria after having whale oil applied to his skin. The infant was breastfed, and his mother also noted flares of the child's AD after she ingested milk, peanut, egg, and chocolate. His family history was remarkable for AD in a grandfather, allergic rhinitis in his maternal grandmother, urticaria in his mother and a maternal aunt, and suspected latex allergy in his mother. The family history was negative for asthma and food allergy. Skin prick tests to standard aeroallergens and a select food panel for AD were performed using the Accu-Set single skin test device (ALK-Abelló, Horsholm, Denmark) and extracts (Greer Laboratories Inc, Lenoir, NC) (Table 1). All SPT results were negative except for cow's milk. Although his symptoms were consistent with an IgE-mediated food allergy to whale, no testing materials were available at that time to verify his history.

The child was seen again at 3½ years of age for further evaluation of his AD and multiple food allergies, IgE mediated and non–IgE mediated. The AD and cough had improved with the removal of milk and whale from his diet. Additional history at that time revealed that the child had recurrent but infrequent episodes of urticaria, cough, congestion, and sneezing, which the mother attributed to allergies to fish and cow's milk. He underwent SPT to multiple aeroallergens and to a panel of foods possibly associated with AD. The child had positive results to multiple foods (Table 1), with appropriate positive and negative controls. Serum radioallergosorbent test IgE confirmed these results. In addition, he underwent patch testing to the same foods using the protocol of Spergel et al[6] and had trace reactions to cow's milk, soy, rye, corn, green bean, beef, and pork.

The child was followed up at 4 years of age, at which time the mother described a recent history of generalized urticaria and oral burning after ingestion of bearded seal. No further

Table 1. Skin Prick and Patch Test Results in the Patient at 11 Months to 4.5 Years of Age*

Antigen	Skin prick testing			Patch testing	
	11 mo	3.5 y	4.5 y	3.5 y	4.5 y
Cow's milk	4+	4+	4+	Tr	Negative
Casein	4+	NP	NP	NP	NP
Soy	0	4+	3+	Tr	Negative
Egg white	0	4+	NP	NP	Tr
Wheat	0	0	NP	NP	NP
Rye	NP	0	NP	Tr	Negative
Oat	0	0	NP	NP	NP
Barley	0	0	3+	NP	NP
Rice	NP	0	3+	NP	NP
Corn	0	4+	NP	Tr	Tr
Potato	NP	0	3+	NP	NP
Green beans	NP	4+	2+	Tr	Negative
Peas	NP	0	NP	NP	NP
Peanut	0	4+	4+	NP	NP
Cashew	NP	4+	4+	NP	NP
Almond	NP	4+	NP	NP	NP
Beef	0	4+	3+	Tr	Negative
Chicken	0	4+	4+	NP	NP
Pork	NP	4+	NP	Tr	Negative
Fish	0	NP	NP	NP	NP
Cod	NP	4+	4+	NP	NP
Flounder	NP	4+	4+	NP	NP
Salmon	NP	4+	4+	NP	NP
Shellfish	0	NP	NP	NP	NP
Shrimp	NP	4+	4+	NP	NP
Crab	NP	0	0	NP	NP
Clam	NP	3+	4+	NP	NP
Bowhead whale	NP	NP	4+	NP	NP
Bearded seal	NP	NP	4+	NP	NP

Abbreviations: NP, not performed; Tr, trace.

* Grading scale: 1+, less than 21-mm erythema; 2+, less than 3-mm wheal and surrounding erythema; 3+, greater than 3-mm wheal and surrounding erythema; and 4+, 3+ with pseudopods.

complaints were noted at that time, and the child was otherwise doing well. The total IgE level obtained at that visit was found to be elevated at 734 IU/mL. He was seen most recently at 4½ years of age. The mother at this time stated the child was doing well with food avoidance, but on the few occasions when he ingested small amounts of cooked bowhead whale and bearded seal meat, he developed urticaria and abdominal symptoms from the former and periorbital and oral angioedema plus oral burning from the latter. Repeated SPT to the same foods revealed that he continued to have positive reactions to multiple foods (Table 1). Patch testing was also repeated owing to the child's continued AD, and he continued to have trace reactions to egg white and corn, but negative reactions to cow's milk, soy, rye, green bean, beef, and pork.

Extracts were prepared from cooked bowhead whale and bearded seal meats provided by the coastal Alaskan population. Each meat was cut into fine pieces and soaked in 0.125-mol/L ammonium bicarbonate at 4°C overnight. The respective extracts were then centrifuged, and the supernatant was passed through a series of graded filters. The filtrates were subsequently dialyzed against 3 changes of distilled water for 24 hours at 4°C in 3,500-Da dialysis tubing, lyophilized, and stored at 4°C. The resultant lyophilized extracts were reconstituted with sterile diluent in a 1:10 wt/vol dilution. The patient underwent SPT with bowhead whale and bearded seal extracts after informed consent was obtained from his mother. His test results were 4+ to both extracts with appropriate positive and negative controls. Ten control subjects underwent SPT with the same extracts and had negative results.

The protein concentrations of the extracts were determined using a modification of the technique of Lowry et al.[7] The bowhead whale extract contained 1,056 μg of protein per milligram of lyophilized extract, whereas the bearded seal extract contained 984 μg of protein per milligram of lyophilized extract.

Separate sodium dodecyl sulfate–polyacrylamide gel electrophoresis gels of the bowhead whale and bearded seal extracts were obtained as previously described.[8] Gels were stained with 0.025% Coomassie blue and revealed multiple protein bands. IgE immunoblots were also obtained as previously described.[8] The proteins from the sodium dodecyl sulfate–polyacrylamide gel electrophoresis gels were transferred to 0.45-μm nitrocellulose membranes. After transfer, the molecular weight standards were cut from the membrane and stained with Coomassie blue. The bowhead whale and bearded seal protein nitrocellulose membranes were washed, blocked with 20% fetal bovine serum (FBS), and incubated overnight with the patient's serum in 10% FBS, with pooled cord serum used as the negative control. A 1:10 dilution of the patient's serum and cord serum were added to 10 μg of electrophoresed bowhead whale and bearded seal extracts. The membranes were washed and incubated for 6 hours at room temperature in mouse anti–human IgE monoclonal antibody diluted 1:5,000 in 10% FBS. They were then incubated overnight in alkaline phosphatase–conjugated goat anti–mouse IgG diluted 1:2,000 in 10% FBS. The molecular weight standards were determined using a calibration curve graphing the log of the control proteins' molecular weight vs their migration distance over the migration distance of the dye front. The membranes were developed, and the molecular weight of each protein was determined using the molecular weight standards.

The immunoblots revealed serum specific IgE binding with the bowhead whale extract, with protein bands at 55 and 90 kDa. IgE binding was also seen with the bearded seal extract, with protein bands at 25, 40, 50, and 90 kDa. The IgE immunoblots with molecular weight standards are shown in Figure 1. We did not perform inhibition immunoblots to evaluate for cross-reactivity between the bowhead whale and bearded seal owing to insufficient patient serum. However, this is a consideration for future studies should additional patients present with similar symptoms.

DISCUSSION

We describe an Inupiaq boy with urticaria after topical whale oil application, urticaria and abdominal symptoms after ingestion of bowhead whale meat, and urticaria and angioedema after ingestion of bearded seal meat. Based on positive SPT reactions to bowhead whale and bearded seal extracts, and demonstration of serum specific IgE binding by immunoblot to these meats, this young child was diagnosed as having IgE-mediated food allergy to bowhead whale and bearded seal.

Adverse food reactions cause a spectrum of clinical manifestations, most often categorized as gastrointestinal, cutaneous, or respiratory. The gastrointestinal hypersensitivity reactions include allergic eosinophilic esophagitis or gastroenteritis, food protein–induced proctocolitis, food protein–induced enterocolitis, and food protein–induced enteropathy. Although this child exhibited gastrointestinal symptoms suggestive of allergic eosinophilic gastroenteritis, a biopsy was not performed so it was not discussed extensively in the case presentation.

The cutaneous manifestations of food hypersensitivity reactions encompass IgE- and cell-mediated reactions. The IgE-mediated disorders include acute and chronic urticaria or angioedema and some cases of AD. Atopic dermatitis can also be due to cell-mediated mechanisms, a category that also includes contact dermatitis and dermatitis herpetiformis. This child had extensive AD, a disorder that affects more than 10% to 20% of children[9] and typically manifests before 5 years of age.[10] Foods and aeroallergens are believed to trigger flares of AD. Furthermore, IgE-mediated food allergies are believed to be more prevalent in children with AD, even if the food is not contributing to worsening of the AD.[11] A careful history can be helpful to direct specific testing when evaluating for the presence of specific triggers. In vitro tests or SPTs for specific IgE to aeroallergens and foods may be performed. These are most beneficial for ruling out potential triggers, particularly for aeroallergens, which have a high negative predictive value for SPTs and in vitro tests for AD.

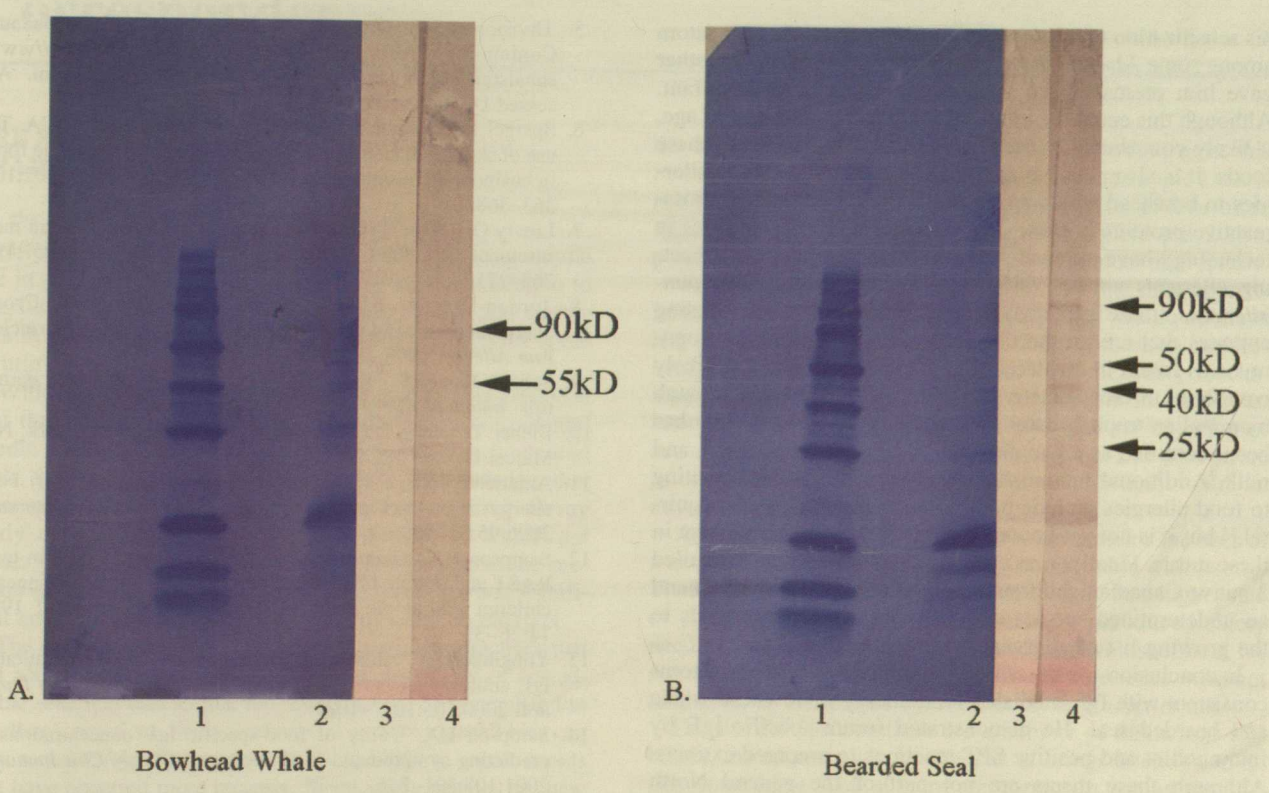

Figure 1. IgE immunoblots of bowhead whale (A) and bearded seal (B) extracts. Lane 1 indicates the molecular weight standard; lane 2, bowhead whale or bearded seal; lane 3, cord blood; and lane 4, the patient's blood. Lanes 1 and 2 represent Coomassie blue stains for protein, and lanes 3 and 4 represent IgE immunoblots.

Positive test results, however, need to be correlated with symptoms and may require controlled food challenges to evaluate for worsening AD.[12] Previous studies[13–15] have suggested that food-specific serum IgE levels may be helpful in diagnosing symptomatic food allergies to egg, milk, peanut, and fish, eliminating the need for controlled food challenges in certain cases. Furthermore, additional studies[16] have confirmed that milk, egg, peanut, soy, wheat, and fish account for up to 90% of the foods found to trigger AD.

An additional method of evaluating for triggers of AD involves patch testing to specific foods and aeroallergens, although patch testing is not currently standardized for this purpose and remains controversial. This can be accomplished by either patch testing to the suspected foods and aeroallergens that were negative on SPTs or by patch testing to all the suspected substances. In this case, the child underwent SPT and patch testing to standard food and aeroallergen panels. Testing for whale and seal was limited to SPT and IgE immunoblots. He developed numerous positive results on each modality, so food elimination diets were performed. As a result of this approach, the mother identified milk and whale as triggers for the child's AD. The remaining foods that the child tested positive to were successfully reintroduced into his diet.

The final broad category of adverse food reactions is respiratory manifestations, which include allergic rhinoconjunctivitis and asthma. Asthma exacerbations are rarely the sole manifestation of a food allergy. However, acute bronchospasm can occur as part of an IgE-mediated anaphylactic reaction to food, in addition to symptoms of allergic rhinitis, gastrointestinal and cutaneous complaints, hypotension, and cardiac dysrhythmias. This child displayed diffuse urticaria, cough, congestion, sneezing, abdominal pain, and angioedema on exposure to bowhead whale, bearded seal, and milk, symptoms of moderate anaphylaxis according to the grading system suggested by Brown.[17] Avoidance of the foods in his diet ultimately led to resolution of these symptoms.

It is of interest that this child developed IgE-mediated allergies to the 2 most common meat sources in his diet. Although not a lot is known about food allergies in indigenous populations, we recognize several applicable generalizations. This child experienced early exposure to whale proteins through whale oil applied topically to his eczematous skin. Since Lack et al[18] reported sensitization to peanuts in young children who had cream containing peanut oil applied topically for AD, it is entirely plausible that this child's early exposure to an allergenic protein in whale oil contributed to

his sensitization to whale meat. Furthermore, as is the custom among some Alaskan native populations, the patient's mother gave him premasticated whale and seal food as an infant. Although this enabled him to eat these foods at an earlier age, it likely contributed to the development of allergies to these foods. It is also possible that the young boy developed allergies to bowhead whale and bearded seal as a result of cross-reactive proteins in these 2 mammals, as recent advances in technology have allowed scientists to categorize cross-reacting allergens among various food categories. Called *pan-allergens*, these proteins possess homologous IgE-binding epitopes that are present in a species.[11] For example, tropomyosins found in crustaceans and panalbumins in fish likely contribute to cross-reactivity among these groups. Although mammalian tropomyosins are nonallergenic, bovine IgG has been identified as a panallergen for beef, lamb, venison, and milk. Additional mammalian foods reported as contributing to food allergies include pork, goat, horse, rabbit, and squirrel,[11] but it is not yet known whether bovine IgG is present in these meats. Finally, a recent study by Roberts et al[19] detailed 3 native Canadian children with food allergies to caribou and an undetermined species of seal, adding these mammals to the growing list of allergenic mammalian foods.

In conclusion, we described an Inupiaq boy with symptoms consistent with IgE-mediated food allergy to bowhead whale and bearded seal. He demonstrated serum specific IgE by immunoblot and positive SPT reactions to prepared extracts. Although these meats are not part of the general North American diet, they are significant sources of nourishment for the coastal Alaskan population, and an allergy to them poses as much of a problem for this child as an IgE-mediated food allergy to chicken, beef, or pork would to an average American child. This is the first known report of an IgE-mediated food allergy to bowhead whale and bearded seal.

REFERENCES

1. Sicherer SH, Teuber S; Adverse Reactions to Foods Committee. Current approach to the diagnosis and management of adverse reactions to foods. *J Allergy Clin Immunol.* 2004;114: 1146–1150.
2. Division of Subsistence, Alaska Department of Fish and Game. Subsistence in Alaska: a year 2000 update. Available at: http://www.subsistence.adfg.state.ak.us/download/subupd00.pdf. Accessed December 15, 2005.
3. University of Michigan Animal Diversity Web: Balaena mysticetus. Available at: http://animaldiversity.ummz.umich.edu/site/accounts/information/Balaena_mysticetus.html. Accessed December 15, 2005.
4. Alaska Department of Labor Alaska census data 2000–2004. Available at: http://almis.labor.state.ak.us. Accessed December 15, 2005.
5. Division of Subsistence, Alaska Department of Fish and Game. Community Profile Database. Available at: http://www.subsistence.adfg.state.ak.us/geninfo/publctns/cpdb.cfm. Accessed December 15, 2005.
6. Spergel JM, Beauoleil JL, Mascarenhas M, Liacouras CA. The use of skin prick tests and patch tests to identify causative foods in eosinophilic esophagitis. *J Allergy Clin Immunol.* 2002;109: 363–368.
7. Lowry OH, Rosenbrough NJ, Farr L, Randau RL. Protein measurement with folin phenol reagent. *J Biol Chem.* 1951;193: 265–275.
8. Jordan-Wagner KL, Whisman BA, Goetz DW. Cross-allergenicity among celery, cucumber, carrot and watermelon. *Ann Allergy.* 1993;71:70–79.
9. Schultz-Larsen F, Hanifin JM. Epidemiology of atopic dermatitis. *Immunol Allergy Clin North Am.* 2002;22:1–24.
10. Bieber T, Leung DY, eds. *Atopic Dermatitis.* New York, NY: Marcel Dekker Inc; 2002.
11. American College of Allergy, Asthma, & Immunology. Food allergy: a practice parameter. *Ann Allergy Asthma Immunol.* 2006;96:S1–S68.
12. Sampson HA, Albergo R. Comparison of results of skin tests, RAST and double-blind, placebo-controlled food challenges in children with atopic dermatitis. *J Allergy Clin Immunol.* 1984; 74:26–33.
13. Yunginger JW, Ahlstedt S, Eggleston PA, et al. Quantitative IgE antibody assays in allergic diseases. *J Allergy Clin Immunol.* 2000;105:1077–1084.
14. Sampson HA. Utility of food-specific IgE concentrations in predicting symptomatic food allergy. *J Allergy Clin Immunol.* 2001;107:891–896.
15. Rance F, Abbal M, Lauwers-Cances V. Improved screening for peanut allergy by the combined use of skin prick tests and specific IgE assays. *J Allergy Clin Immunol.* 2002;109: 1027–1033.
16. Lever R, MacDonald C, Waugh P, Aitchison T. Randomized controlled trial of advice on an egg exclusion diet in young children with atopic eczema and sensitivity to eggs. *Pediatr Allergy Immunol.* 1998;9:13–19.
17. Brown SG. Clinical features and severity grading of anaphylaxis. *J Allergy Clin Immunol.* 2004;114:371–376.
18. Lack G, Fox D, Northstone K, et al. Factors associated with the development of peanut allergy in childhood. *N Engl J Med.* 2003;348:977–985.
19. Roberts JR, Gerstner TV, Grewar DA, et al. Allergy to caribou and seal meats in Inuit children: a report of three cases. *J Allergy Clin Immunol.* 2006;117:S42.

Requests for reprints should be addressed to:
Laura M. Moore, MD
56th Medical Group/56 MDO5/560MA
7219 N Litchfield Rd
Luke AFB, AZ 85309
E-mail: Laura.Moore@luke.af.mil