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Occupational asthma in the commercial fishing industry: a case series and review of the literature

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ABSTRACT

We present a case series of snow crab-induced occupational asthma (OA) from a fishing and processing vessel, followed by a review of OA in the commercial fishing industry. OA is typically caused from an IgE-mediated hypersensitivity reaction after respiratory exposure to aerosolized fish and shellfish proteins. It more commonly occurs due to crustaceans, but molluscs and fin fish are implicated as well. Standard medical therapy for asthma may be used acutely; however, steps to reduce atmospheric allergen concentrations in the workplace have proven to be preventive for this disease.

Key words: occupational asthma, snow crab, case series, review

INTRODUCTION

Occupational asthma (OA) accounts for 10–15% of all cases of adult onset asthma [1] and occurs in a variety of industries. OA has been well described in the commercial fishing industry, particularly in the handling and processing of crustaceans. As the exponential growth of the world population has led to rising food protein demands and subsequent increases in commercial fishing, OA incidence has the potential to increase [2]. The purpose of this paper is to review the causes, risk factors, and prevention strategies for occupational asthma in the commercial fishing industry. This will help physicians and others involved in maritime health to effectively manage this clinical entity.

MATERIAL AND METHODS

The authors searched all articles from 1960 to 2010 in Pub-Med and the Pascal French database with the following key-words: occupational asthma, occupational allergies, occupational dermatitis, seafood, and fishery industry. Additionally, case records from a maritime health clinic in Brest, France and a maritime telemedicine service in Washington, DC, USA were searched for illustrative cases of OA.

CASE SERIES

A search was made of case records of a maritime telemedicine service in Washington, DC, and four cases of occupational asthma were identified aboard a snow crab processing vessel off the coast of Alaska. A search was made of case records of a maritime health clinic service in Brest, France, and no cases of OA in workers in the commercial fishing industry were found.

The first case was that of a 20-year-old man with a history of shellfish allergy (which escaped the notice of the pre-employment screening process) and asthma who had onset of shortness of breath and itching skin within 6 hours of starting duty on his first day on board. He also experienced vomiting and tachycardia. At the suggestion of his co-workers, he changed clothing when away from work and

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his symptoms improved. However, his symptoms recurred whenever he approached the door of the processing plant. He was treated with albuterol and diphenhydramine with some improvement. He was repatriated off the vessel and no other follow-up information was available.

The second case was that of a 34-year-old man with symptoms of an upper respiratory tract infection associated with dyspnea. He had no rash or wheezing, and no history of shellfish allergy. He had normal vital signs and his oxygen saturation was 99% in room air. He was treated on board with nebulised albuterol with some relief, as well as prednisone and amoxicillin. Although he subsequently had a negative allergy panel at the clinic in Dutch Harbor, Alaska, his symptoms recurred whenever working in the processing plant, making the diagnosis of OA very likely.

The third case was that of a 26-year-old man who presented with shortness of breath and wheezing. His symptoms improved temporarily with diphenhydramine and albuterol, but his symptoms then progressively worsened until he was symptomatic wherever he was onboard. At time of evacuation he was unable to walk due to his marked dyspnea and had oxygen saturations from 80% to 85%. Within minutes of evacuating the ship, his symptoms resolved, and he then declined further medical evaluation when ashore. No follow-up information was available.

The fourth case was that of a 39-year-old man who presented with dry cough and shortness of breath. His symptoms decreased at night but were more marked during the day while working and were associated with visible respiratory distress. On examination, he was wheezing and had oxygen saturation of 97% in room air and a pulse of 80 bpm. He received diphenhydramine, oxygen, albuterol, and azithromycin with improvement and was transported ashore.

DISCUSSION

AETIOLOGY

The case series presented above is an example of snow crab asthma, one of the more well-described causes of OA in the fishing industry. The snow crab is a species of crab fished and processed mainly in the Arctic waters of Canada, Alaska, and Russia. In 1979 Orford described 17 cases of asthma and allergic rhinitis in a queen crab plant (synonym of the snow crab) [3, 4]. Subsequent studies in multiple snow crab processing plants revealed a prevalence range from 9 to 50 percent. In offshore crab-processing ships asthma-like symptoms occur in up to 16 percent of fishermen [5–7].

Other crustaceans and molluscs have been found to cause OA in the fishing industry. Occupational king crab exposure was reported to be associated with wheezing in a case series of 47 patients with a prevalence of 9% of king crab workers in Alaska [8]. Other crustaceans reported to cause OA include the Atlantic rock crab [9], lobster [10––12], prawn [13, 14], and shrimp [12, 15, 16]. Of note, there is a high prevalence (36–57%) of OA in shrimp processing plants [17].

Molluscs are also implicated in OA; however, with a prevalence well below that of crustaceans. *Perna Cannaliculus* (New Zealand green-lipped mussel) is described as causing a 16.5% prevalence for OA in a population of 223 workers. But the diagnostic criteria in this study for OA was not well controlled [18]. Other data on mollusc-induced OA are limited to case reports related to exposure to clams [15, 19], scallops in restaurant workers [20], cuttlefish in Polish deep sea fisherman [21], and abalone in a diver [22].

Fin fish are also implicated in OA. In a Polish study, fish allergen-induced asthma was suspected in fish-processing plant workers with a prevalence of 2% [23]. Fin fish species implicated in OA include salmon, tuna, hake, and trout [24––27]. A more recent review reports a prevalence of work-related asthma-like symptoms as high as 7% in bony fish processing workers [28].

OA is not always caused by allergens from fish products themselves, but also from parasites or other contaminants encountered in fish processing. Parasites such as *Anisakis* simplex have been implicated in causing OA in fishmongers, chicken farm workers who use fish protein-based chicken feed, and in frozen fish processing workers [29–31]. Red coral is now well known in Japan to be responsible for asthma in lobster fishermen [32]. Respiratory exposure to a tiny oyster parasite named hoya caused OA in up to 29% of Japanese oyster farm workers [33].

Preservatives used in fish and seafood processing may also cause OA: Sodium metabisulfite is one chemical preservative used in crustacean processing that has been found to probably be responsible for OA in fishermen and shrimp-processing workers [34]. Even “natural” additives such as garlic, mustard, and anise are well-known occupational asthma triggers and are often used in the fishery industry [35, 36].

PATHOPHYSIOLOGY

Snow crab asthma is an allergic asthma mediated by IgE after exposure to aerosolized thermo-stable proteins. The rate of immunologic sensitization in workers exposed to snow crabs is very high. In a study of 119 exposed workers, 97% had a positive radioallergosorbent test (RAST) for IgE antibodies against snow crab proteins [37]. Although not every patient with a positive RAST will develop OA, there is a positive relation between the occurrence of OA and the positivity of RAST tests. An alternative pathophysiology of snow crab-related lung disease may be hypersensitivity pneumonitis caused by dinoflagellate contamination rather than snow crab allergens themselves [7].

The pathophysiology of OA stems from immune sensitization to seafood proteins (from meat, endolymph, exoskeleton, blood) via respiratory exposure when those proteins are aerosolized during the work process [38]. Most of these allergens are high molecular weight proteins such as tropomyosin in shrimp, prawns, and scallops and parvalbumin from fish [39]. Cross-reactivity can occur causing patients to be allergic to multiple species of seafood. This may be important in job reassignment as part of the treatment plan for seafood workers with OA. Classic OA stems from an IgE-mediated hypersensitive reaction leading to airway inflammation and bronchospasm. However, IgG-mediated mechanisms are implicated in some cases of coral exposure and from prawn and salmon processing [13, 14, 24, 40].

Typical exposure and subsequent sensitization comes from wet aerosols encountered in the processing of fresh seafood products. However, exposure may also occur by vaporized allergens inhaled during the cooking of crab and lobster [9, 10, 13, 20, 24, 41, 42]. Furthermore, dry aerosol exposures have been described for shrimp, clam, fish, and *anisakis* simplex [15, 16, 19, 25, 29]. These are summarized in tables 1 and 2.

Atmospheric allergen concentration is a major professional risk factor responsible for the development of OA in the commercial fishing industry [39]. The most high-risk work stations for snow crab workers are boiling, butchering stations body leg stations; concentrations in those stations on vessels have been measured at 1 657 ng/m^3, 7 443 ng/m^3 and 5 061 ng/m^3 respectively [7, 37, 41]. Although butchering stations account for only 25% of snow crab plant workers, this role represents 70% of asthma cases, highlighting the importance of atmospheric allergen concentrations [7, 37, 41, 42].

Across seafood industries, high-risk work stations include butchering, de-gilling, cracking, and boiling stations for crab; blowing of prawns; washing of shellfish; tailing and cooking of lobster; degutting and cooking of fish; and handling fish food [38, 39]. The loading and bagging of fish-meal made from pilchards and anchovies may also result in high atmospheric allergen concentrations [38].

The proteins implicated in crustacean associated OA have similar molecular weights as those implicated in non-sea-food OA such as flour (24%), laboratory animals (11.7%), or papaďn (34.5%) [43]. In both seafood and non-seafood OA, the pathophysiology appears to be IgE-mediated and from pulmonary exposure due to mechanized processes releasing atmospheric allergens in the workplace. Thus, the higher incidence of OA due to crustacean exposure compared to molluscs or other seafood species may be related to the work processes promoting aerosolization and not just to the type of protein itself. For example, the snow crab season is fairly short, but with fisherman and processors working intensive, extended hours. Additionally, post-catch processing for crab, shrimp, and prawns may aerosolize proteins. This gives a more concentrated exposure of allergens to the worker. This contrasts with the less intense fishing practices and minimal post-catch processing for molluscs, such as scallops and abalone, where the incidence of OA is less. This concept is further supported by reports of OA in cuttlefish fishermen. Those that develop OA are those that process cuttlefish in the holds of the fishing vessel with little ventilation [21]

Table 1. Routes of respiratory allergen exposure for species causing OA

Wet Aerosols from fresh products	Vapours during cooking	Dry Aerosols
Crab Prawn Cuttlefish Fish (salmon, hake) Anisakis Coral Hoya	Crab Lobster Mussel	Shrimp Clam Fish Anisakis

Table 2. Host risk factors for the development of OA

Atopy	Smoking habits
Snow crab Prawns Shrimps Clams Lobsters	Prawns Snow crab Mussels Salmons

PREVENTION AND TREATMENT

Prevention strategies involve adequate ventilation and work process alterations that limit human respiratory exposure to seafood allergens. In one published report, reducing the respirable particulate ranges of allergens from a mean of 5 mg/m^3 to 0.01 mg/m^3 in the workplace reduced the prevalence of OA in a salmon processing plant from 8.2% to zero [23]. Additionally, in a prawn-processing factory, improvements in the ventilation that cut the atmospheric allergen concentration ten-fold resulted in the elimination of new cases of OA when the prevalence had previously been 36% [13]. Gautrin demonstrated that a high cumulative exposure to crab allergens was associated with OA, further supporting the theory that daily respiratory allergen exposure should be minimized [44].

When evaluating cases of potential OA, patient-related factors are important for consideration as well. These are summarized in table 2. Smoking is found to be a risk factor in developing OA after exposure to prawns, snow crabs, mussels, and salmon [5, 14, 18, 24]. Also, the presence of other previous or concurrent atopic conditions may predispose the development of OA from snow crabs, prawns, shrimps, clams, and lobsters [5, 13, 15, 39]. Thus, smoking cessation, optimizing treatment of other atopic conditions, or job reassignment for workers with these predisposing conditions may be useful. Otherwise standard medical therapy is recommended for treatment and allergen avoidance as a prophylactic measure.

Snow crab asthma has a high clinical and social impact as the effects may remain long after exposure. In a 5-year follow-up of 31 cases, Malo demonstrated a slow improvement in FEV1 in the first year followed by a plateau of bronchial hyperresponsiveness at 2 to 5 years. Additionally, IgE levels are high at 2 years for 29% and 16% at 5 years. At the end of the follow-up, one-third of cases had an ongoing requirement for asthma medication [45]. This phenomenon was not demonstrated in our study since follow-up information was not typically available to the telemedicine service, which mainly treated acute cases.

CONCLUSIONS

Occupational asthma is a significant problem in the commercial fishing and fish-processing industry. Crustaceans such as snow crabs, prawns, and molluscs are more common than fin fish in causing this disorder. Most cases result from an IgE-mediated hypersensitivity reaction after respiratory exposure to aerosolized fish and shellfish proteins. Preventive strategies such as ventilation improvements and work process changes that reduce atmospheric allergen concentrations have been shown to be extremely effective in reducing the burden of this occupational disease. In addition to standard medical therapy for asthma, special considerations may need to be made for patients who are smokers or who have other pre-disposing atopic conditions.

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