CONSUMPTION OF VISCERA AS THE MOST IMPORTANT RISK FACTOR IN THE LARGEST OUTBREAK OF SHELLFISH POISONING IN HONG KONG, 2005

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Abstract. Poisoning from shellfish toxins is associated with significant morbidity worldwide. During 10-15 March 2005, 36 clusters of shellfish poisoning related to consumption of fresh scallops (*Atrina vexillum*) were reported to the Center for Health Protection, Department of Health Hong Kong. We conducted a case-control study to identify the risk factors associated with shellfish poisoning. Detailed demographic, clinical, shellfish consumption data of these subjects were collected using standardized questionnaires. Fifty-eight cases and 44 controls were identified. The mean age for the cases was 37.5 years (range 10 – 81 years); 45% (n=26) were male. Ninety-five percent had onset of symptoms within 12 hours of consumption of scallops (range: 10 minutes to 30 hours, median: 45 minutes). Dizziness (87.9%) and blurred vision (53.4%) were the predominant symptoms. The mean number of pieces of scallop meat and viscera taken by the cases were 3.7 and 3.6, respectively, significantly higher than that for the controls, which were 1.6 (p<0.001) and 0.5 (p<0.001), respectively. Forty-two percent (n=22) and 19% (n=7) of cases and controls, respectively, took soup/sauce from the same dish that was cooked with the scallops (p=0.02). Consumption of scallop viscera was identified as the only significant risk factor (Adjusted OR=9.93, p=0.001) after adjusting for other risk factors. The result show that consumption of scallop viscera is an important risk factor for shellfish poisoning. The public should be warned specifically in health education messages to avoid eating viscera of scallops.

INTRODUCTION

Shellfish poisoning is a significant public health problem in many countries. It accounts for 7.4% of marine intoxications in the USA (Isbistr and Kiernan, 2005). Four major toxic syndromes resulting from shellfish ingestion are paralytic shellfish poisoning (PSP), neurotoxic shellfish poisoning (NSP), amnestic shellfish poisoning (ASP) and diarrhetic shellfish poisoning (DSP). PSP is by far the commonest and carries a case-fatality rate ranging from <1% in North America (Mons *et al,*1998), to 14% in Southeast Asia and Latin America (Gessner and Middaug, 1995).

Despite evidence for increasing cases of PSP globally (Bricelj *et al,* 2005), there is a deficiency of knowledge about dose-response factors in shellfish poisoning from field epidemiological studies. The risk of shellfish poisoning from ingestion of meat versus viscera of shellfish is not well quantified, and the threshold amount of shellfish intake resulting in symptoms is not precisely known. The lack of such information hinders the development of effective preventive and educational measures against shellfish poisoning.

Shellfish consumption is common in Hong Kong and shellfish poisoning poses a threat to both local people and tourists in this international city. In March 2005, an unusually large outbreak of shellfish poisoning was investigated by the Department of Health (DH). This study describes the epidemiology of the outbreak and analyzes various factors between shellfish consumption and development of shellfish poisoning.

MATERIALS AND METHODS

Recruitment of subjects

In Hong Kong, doctors are required by law

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Fig 1–*Atrina vexillum.*

to report food poisoning incidents to the DH. On March 14, 2005, we received one incident of food poisoning in which three persons reported clinical symptoms compatible with shellfish poisoning after eating one type of fresh scallops, later identified as *Atrina vexillum* (Fig 1). On March 15, we received four other food poisoning incidents associated with the same type of scallops. We promptly alerted the public via a media announcement on the same day. To promote case finding, we set up a hotline for public enquiry and reporting of shellfish poisoning. We sent letters to about 11,000 doctors asking them to report patients presenting with symptoms of shellfish poisoning.

We conducted a case-control study to determine the risk factors for the development of shellfish poisoning symptoms. A case-patient was a person who developed at least one of the following neurological symptoms: (blurred vision, double vision, oral numbness, limb weakness, limb numbness) after consuming fresh scallops (cooked or raw) within 48 hours during 10-20 March. We defined controls as cases' family members or friends who consumed fresh scallops at the same meal but did not develop symptoms.

Data collection

For each case and control, we administered a standardized questionnaire through telephone interviews by trained public health doctors and nurses. We collected demographic and clinical data (age, sex, co-morbidities, medication use), shellfish consumption (date, time and location of purchase; method of preparation of shellfish; date and time shellfish were eaten; amount of shellfish meat and viscera consumed) and clinical manifestations (time to onset of symptoms and duration of symptoms).

Food sampling and testing

We reported all shellfish poisoning clusters to the Food and Environmental Hygiene Department (FEHD) to trace the source of the fresh scallops. The FEHD collected fresh scallop samples from local markets patronized by the case-patients. The fresh scallop samples were tested at the Biotoxins Laboratory of the DH using standardized mouse bioassay (MBA) for PSP toxin (PSTs) (Halstead and Schantz, 1984). We also sent samples to a laboratory in New Zealand which carried out testing for NSP toxins (NSTs).

Data analysis

Data analysis was performed using Statistical Package for Social Sciences (SPSS) version 13.0. Univariate analysis (Student's *t*-tests, chi-square tests) was used to assess the variation/association of predictive values with case status. Variables which demonstrated'variation/association with a p-value less than 0.2 were entered into a binary logistic regression model. Adjusted odds ratio (AOR) and their 95% confidence intervals were estimated. For all statistical tests, association was considered statistically significant at $p<0.05$.

RESULTS

Patient characteristics and clinical presentation

Altogether, we identified 58 cases in 36 clusters of shellfish poisoning during March 10-20, 2005 (Figs 2 and 3). The mean age of the cases was 37.5 years (range 10 - 81 years); 45% (n=26) were male. Ninety-five percent had onset of symptoms within 12 hours of consuming fresh scallops (median: 45 minutes). The time to onset of symptom after taking scallops correlated negatively with the number of pieces of scallop viscera ($r=-0.27$, $p=0.045$) and scallop meat ($r=-0.35$, $p=0.007$) consumed. Dizziness (87.9%) and blurred vision (53.4%) were the predominant neurological symptoms, which were

Table 1
Symptoms in the cases (N=58).

Symptoms	Number (%)
Dizziness	48 (87.9)
Blurred vision	31 (53.4)
Limb weakness	26 (44.8)
Limb numbness	23 (39.7)
General weakness	23 (39.7)
Nausea	17 (29.3)
Leg cramps	10 (17.2)
Abdominal pain	10 (17.2)
Headache	6 (10.3)
Diarrhea	6 (10.3)
Vomiting	4 (6.9)
Double vision	4 (6.9)
Muscle pain	4 (6.9)
Oral numbness	4 (6.9)

compatible with PSP/NSP (Table 1). The median duration of symptoms was 12 hours (range: 1 - 228 hours). Symptom duration did not show statistically significant correlation with the amount of scallop viscera ($r=0.15$, $p=0.26$) or meat intake ($r=-0.15$, $p=0.27$).

Forty-eight percent (n=27) of patients sought medical care, but none required hospitalization and all recovered uneventfully. Following the media announcement on March 15, the outbreak stopped abruptly and no new patients had symptom onset after March 15 (Fig 4).

Table 2 shows a comparison between the 58 cases and 44 controls. The cases had a higher mean age than controls ($p=0.01$), but they showed comparable gender distribution. The mean number of pieces of scallop meat and viscera taken by the cases were 3.7 and 3.6, respectively; significantly higher than that for controls, which were 1.6 ($p<0.001$) and 0.5 ($p<0.001$) respectively. Four of the 8 cases who did not eat scallop viscera took only 1 piece of scallop meat. Forty-two percent (n=22) and 19% (n=7) of cases and controls, respectively, took soup/sauce from the same dish that was cooked with the scallops ($p=0.02$). There was no significant difference between the cases and controls in the way the scallops were cooked, (steamed, fried, boiled, barbequed). No cases took scal-

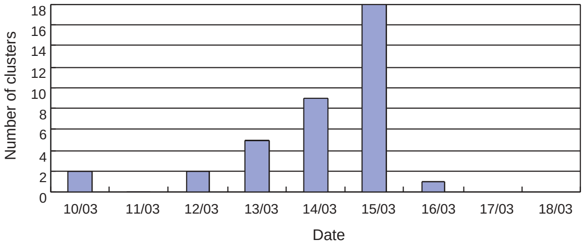

Fig 2–Onset dates of the 36 shellfish poisoning clusters.

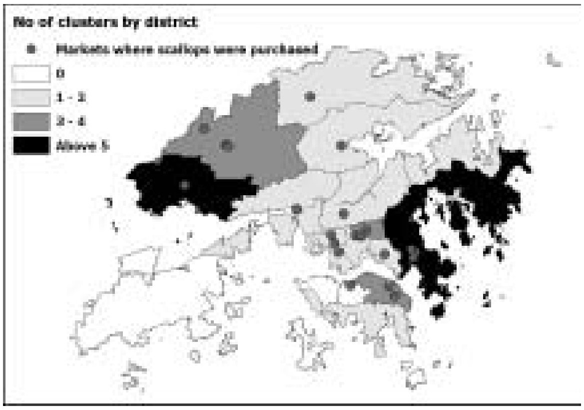

Fig 3–Distribution of clusters in Hong Kong.

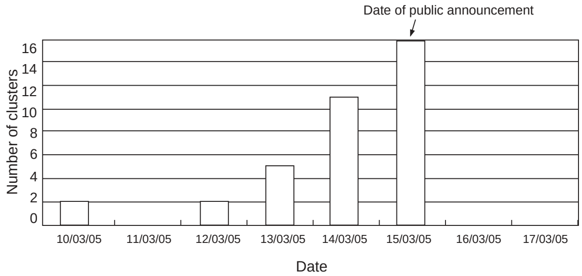

Fig 4–Date of purchase of shellfish for the 36 clusters.

lops with alcohol.

In the binary logistic regression model, we included "number of pieces of meat taken", "number of pieces of scallop viscera taken" and "took soup/sauce from the dish with the scallop" as independent categorical variables. The results are shown in Table 3. The only statistically significant risk factor was taking three or more pieces of scallop viscera (Adjusted OR = 126.19, 95%CI: 8.47 to 1879.17). Our model

Table 2
Characteristics of cases and controls.

Characteristics	Cases (n=58)	Controls (n=44)	Crude odds ratio	p-value
Age				
Mean±SD	37.5±13.7	27.5±18.3	N/A	0.01[a]
Gender				
Male	26	22	N/A	0.69
Female	32	22		
No. of pieces of scallop meat taken				
1	7	27	1.0 (baseline)	<0.001[a]
2	9	10	3.5	
3 or more	42	7	23.1	
Mean±SD	3.7±1.9	1.6±0.9		<0.001[a]
(Range)	(1-10)	(0.5-5)		
No. of scallop viscera taken				
0	8	29	1.0 (baseline)	<0.001[a]
1	3	9	1.2	
2	9	5	6.5	
3 or more	38	1	137.8	
Mean±SD	3.6±2.3	0.5±0.8		<0.001[a]
(Range)	0-13	0-3		
Cooking method				
Steamed	46	35	N/A	0.55
Fried	3	4		
Boiled	7	5		
Barbequed	2	0		
Took soup/sauce from the dish with the scallop[b]				
Yes	22	7	3	0.02[a]
No	31	30		
Alcohol consumption				Not calculated since no cases consumed alcohol
Yes	0	2	N/A	
No	0	0		

[a]Statistically significant
[b]Information incomplete as some subjects cannot recall well on this question

does not demonstrate intake of scallop meat as an independent risk factor after adjusting for number of scallop viscera intake. However, readers should note that the respective confidence intervals are very wide.

Food sampling and testing

The fresh scallops in this outbreak were purchased from multiple local suppliers in 21 different markets all over Hong Kong. Mainland China and Vietnam were implicated as possible sources, but results were inconclusive due to the complicated distribution channels.

Ten fresh scallops were collected from local markets patronized by the cases. Results for PSP and NSP were negative. There was no leftover shellfish from the case-patients available for laboratory analysis.

One week after the outbreak, the algae *Alexandrium catenella* and *Alexandrium tamarense* (which are associated with PSP) were found in water samples collected in fish culture zones around Hong Kong. There was limited information to link this phenomenon to the outbreak.

Table 3
Results of binary logistic regression analyses showing adjusted odds ratios for variables associated with being case-patients.

Independent variable	Adjusted odds ratio	95% CI		p-value
		Lower	Upper	
Age (per year)	1.03	0.98	1.07	0.27
No. of pieces of scallop meat taken				
1 *vs* 2	2.08	0.22	19.50	0.52
1 *vs* 3 or more	1.26	0.13	11.8	0.84
No. of scallop viscera taken				
0 *vs* 1	2.12	0.27	16.82	0.48
0 *vs* 2	4.86	0.60	39.75	0.14
0 *vs* 3 or more	126.19	8.47	1879.17	<0.001[a]
Took soup/sauce	1.60	0.37	6.93	0.53

[a]Statistically significant

DISCUSSION

This study reports the largest outbreak of shellfish poisoning in Asia recently. To our knowledge, this is the first field epidemiological investigation that identifies scallop viscera consumption as the most important risk factor of shellfish poisoning. Consumption of three or more pieces of scallop viscera was associated with a greatly elevated risk of shellfish poisoning. These epidemiological observations conform to laboratory studies which identified a higher concentration of PSTs and NSTs in the viscera than in the meat of scallops (Bravo *et al*, 1999; Van Apeldoorn, 2001). Eating viscera together with the meat of scallops is a common habit in Hong Kong. Our findings highlight the need to advise the public specifically about the high risk of shellfish poisoning associated with eating scallop viscera.

Although scallop meat intake was not shown to be an independent risk factor in this study, 8 out of the 58 cases took only scallop meat, and 4 of them only ate one piece of scallop meat. Therefore, scallop meat also poses a small but non-negligible risk of shellfish poisoning.

The clinical presentation of shellfish poisoning in this outbreak was generally consistent with PSP/NSP in terms of incubation period, proportion of neurological symptoms and duration of illness. We reviewed all known shellfish poisoning outbreaks in Hong Kong during 2000-2004 and found that all were PSP-related. A notable feature of this outbreak was that cases experienced relatively mild symptoms and there was no hospitalizations or deaths, unlike PSP outbreaks in the West, with more serious clinical manifestations (Gessner and Middaug, 1995; Isbistr and Kiernan, 2005). This has been a feature of shellfish poisoning in Hong Kong in recent years. Genetic susceptibility factors and variation in toxin nature and amount in shellfish may explain this phenomenon. The literature also suggests that there is considerable individual variation in the level at which PSP intoxications occur (Kontis and Goldin, 1993). The possibility of NSP cannot be excluded. Although human cases of NSP are mainly localized to the Gulf of Mexico, the East coast of Florida and New Zealand, microplankton associated with NSP have been found in Asia and reported in the literature (FAO, 2004).

The negative laboratory results in this study are not unexpected due to the unavailability of leftover scallops from the patients' meals, different batches of scallops from different suppliers sampled from the markets, the relatively small number of samples collected for laboratory analysis, and several documented limitations of MBA in terms of sensitivity and precision (Jellett *et al*, 2002). It is not unusual to have negative toxin identification in shellfish poisoning, even when human fatalities are involved (Noguchi *et al*, 1994). While more sensitive tests (*eg*, HPLC, MIST Alert) are being developed to detect PSP toxins, epidemiological investigations remain the most important tool in assessing the risk of shellfish poisoning.

This outbreak demonstrates that shellfish poisoning can affect many people over a wide geographical area within a short time. An important lesson is that public announcements via the media prove highly effective in halting the progression of an outbreak. Risk communication has also been effective in other countries where outbreaks related to recreational harvesting of contaminated shellfish have occurred (Morris *et al*, 1991). Public health control measures are especially important for places like Hong Kong, where a high proportion (75%) of shellfish are imported from many different places. Unlike some countries, such as USA, where shellfish is sourced from certified growers with regular surveillance (FAO, 2004), Hong Kong finds such monitoring programs difficult to apply due to a number of limiting factors. These factors include the large variety of shellfish products marketed in Hong Kong, insufficiency of documentation of harvesting source, numerous sources of importers and distributors, short holding time of live shellfish, and so on. Due to such limitations imposed by the market, the best alternative is to identify risk factors associated with shellfish poisoning and communicate risks to the public promptly when an outbreak occurs (Ivash, 2002).

In summary, in a large outbreak of shellfish poisoning in Hong Kong, consumption of three or more pieces of scallop viscera was identified as the most important risk factor for developing shellfish poisoning symptoms. Scallop meat intake poses a smaller but non-negligible risk. Early public announcements are highly effective in preventing further cases.

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