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Beriberi Outbreak among Myanmar and Thai workers in a Factory in Chachoengsao Province, Thailand, 2012-2013

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Abstract

Beriberi is a clinical syndrome which develops from prolonged severe thiamine deficiency in diet. In July 2013, the Ministry of Public Health, Thailand received reports of three deaths among Myanmar workers in a factory. We identified suspect beriberi cases, reviewed clinical history and conducted a survey among both Myanmar and Thai workers in the factory. Blood thiamine levels were measured and foods served in the factory canteen were also examined. Seventeen suspect cases (attack rate = 17%) were identified, with median age of 26 years (range 20-30 years) and male to female ratio of 3.3:1. All fatalities were young men (case fatality proportion = 17.6%). Prevalence of thiamine deficiency among Myanmar and Thai workers were 7.1% (95% CI = 0-22.0) and 26.7% (95% CI = 1.3-52.0) respectively. This outbreak was likely to be caused by long exposure to low thiamine intake and heavy physical activities. After distributing thiamine supplements and improving diet, no more cases occurred. We recommended improving hospital staff's ability to differentiate beriberi from other cardiomyopathies and neurologic diseases, and raising awareness of thiamine deficiency in this area.

Keywords: beriberi, thiamine deficiency, malnutrition, occupational health

Introduction

Beriberi is a clinical syndrome, resulting from prolonged severe deficiency of thiamine in diet. Thiamine is vitamin B1 which plays a key role in carbohydrate metabolism and also an important factor for function of the nervous system. Persistent thiamine deficiency for 2-3 months can lead to disability and death. It occurs in people with poor diet, anti-thiamine foods (betel nut and fermented fish), heavy physical activities and special conditions like pregnant women, alcoholics and refugee population.[1]

Beriberi can present in adults with cardiomyopathy (cardiac or wet beriberi) and peripheral neuropathy (dry beriberi). Cardiac beriberi can cause edema, high cardiac output and ventricular failure, and death may occur abruptly from congestive heart failure. Dry beriberi is characterized by polyneuropathy with paraesthesia of extremities (especially legs), reduced knee jerk and other tendon reflexes, progressive severe weakness and muscles wasting.[1]

Beriberi has been reported since thousands of years ago and remains in many parts of Asia. Today with rising standards of living, beriberi has become a rare disease all over the world. Despite that since 2000, some beriberi outbreaks were reported in West Africa[2,3], Brazil[4,5,6], Gambia[7], Somalia[8] and Taiwan[9]. In Thailand, one outbreak was reported among commercial fishermen during 2005.[10]

In April 2013, three deaths of unknown cause among Myanmar workers from Factory A in Chachoengsao

Province, Thailand were reported to the Bureau of Occupational and Environmental Diseases (BOED), Department of Disease Control, Ministry of Public Health. As a result of investigation by BOED, they suspected either chemical poisoning or beriberi. Thus, they recommended providing thiamine rich foods (beans) and thiamine supplements to the workers. Two months later, since laboratory results for chemicals were negative, they notified the Bureau of Epidemiology in July 2013 for further investigation. Therefore, our team was sent to conduct an investigation from 10-12 Jul 2013 to verify the outbreak, confirm the diagnosis, determine the cause, and provide recommendations to prevent further cases and deaths.

Methods

Study among Myanmar Workers

A cross-sectional study was conducted among Myanmar workers in the factory during July 2013. Case definition of beriberi was developed after reviewing medical records and interviewing hospital staff, clinicians and head of the factory workers. A suspect case was defined as a Myanmar factory worker with at least two of the followings: leg pain, tingling or burning sensation of extremities, numbness of extremities, unable to elevate leg, chest pain, leg edema, dyspnea or diagnosed with acute heart failure from November 2012 to July 2013.

We conducted active case finding in the factory by interviewing face-to-face with all Myanmar workers using a semi-structured questionnaire and reviewing medical records of patients diagnosed with beriberi in provincial and district hospitals. Venous blood samples were collected from all suspect cases and tested for thiamine pyrophosphate (TPP) levels using high-performance liquid chromatography (HPLC).

Study on Blood Thiamine Level

We conducted a cross-sectional study on prevalence of thiamine deficiency among Thai and Myanmar workers in the factory during July 2013. Of total 180 workers in the factory, 100 were Myanmar while 80 were Thai. We selected approximately one-seventh of Myanmar workers and one-fifth of Thai workers by stratified simple random sampling from lists of Thai and Myanmar workers. A total of 29 workers were selected, including 14 Myanmar and 15 Thai workers. We interviewed each of them using a questionnaire to obtain information on demographics and risk factors for thiamine deficiency. In addition, we tested all sampled workers for blood TPP level using HPLC to identify prevalence of thiamine deficiency. The reference value for TPP in healthy volunteers was 120 ± 17.5 nmol/L.[11] In this outbreak, according to the laboratory that we sent for testing, thiamine deficiency was defined as TPP level of less than 116 nmol/L.

Data Analysis

Data analysis was performed using R software (version 3.0.1). Statistical significance was assessed by Pearson's chi-squared test or Fisher's exact test for categorical variables, and Student's t-test or Wilcoxon rank sum test for continuous variables. P-value less than 0.05 was considered as statistically significant.

Environmental Survey

As an environmental survey, we observed the working areas and process of food preparation, cooking and serving in the factory canteen as well as workers' rooms. Food samples from the canteen were collected and tested for thiamine by in-house method based on the Association of Analytical Communities (AOAC) 2011 to estimate thiamine intake of workers and compare with recommended dietary allowance (RDA) for adults.[11]

Results

Study among Myanmar Workers

After reviewing medical records in the hospitals and searched for suspect beriberi cases from November 2012 to July 2013, we identified four suspect cases who were Myanmar workers. Three of them died in the hospital. All four Myanmar cases were young men aged 18-27 years. Their onset dates were from November 2012 to March 2013. Symptoms included fever, numbness of extremities, weakness, leg pain, leg edema, dyspnea, chest pain and poor appetite. One case had rapid increase of pericardial effusion (Figure 1). One case recovered and survived after receiving thiamine supplements.

In the factory, we identified 13 suspect beriberi cases among 100 Myanmar workers by active case finding. Total of 17 suspect beriberi cases were identified, with case fatality rate of 17.6% and attack rate of 17%. Median age of suspect cases was 26 years (range 20-30 years) and male to female ratio was 3.3:1. Two of them had thiamine deficiency, with TPP blood levels of 97 nmol/L and 113 nmol/L.

All 17 suspect cases had signs and symptoms of both wet and dry beriberi (Figure 2). Symptoms of peripheral neuropathy included leg pain, numbness of extremities, weakness, burning sensation, inability to stand and tingling sensation. Symptoms of cardiomyopathy were leg edema, dyspnea, chest pain and chest discomfort. Gastrointestinal symptoms consisted of poor appetite, abdominal pain, vomiting and nausea.

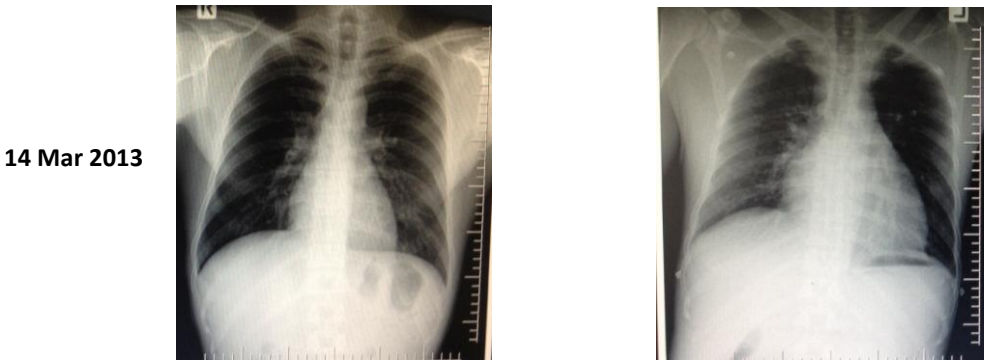

Figure 1. Chest X-rays of a worker with beriberi showing pericardial effusion in Factory A, Thailand, March 2013

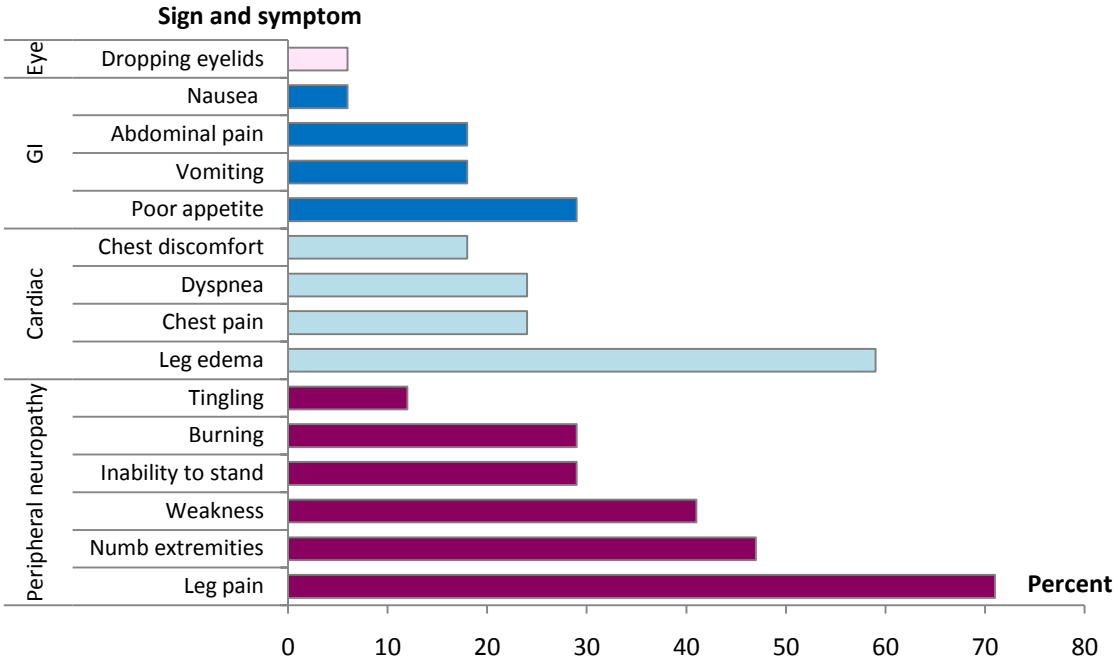

Figure 2. Signs and symptoms of suspect beriberi cases among Myanmar workers in Factory A, Thailand, November 2012 to July 2013 (n=17)

The first case's onset date was in November 2012. Number of new cases peaked in March 2013 and began to decrease in April when our team conducted the investigation. Out of total 17 suspect cases, one case aged 45 years old had symptoms for five years and thus, was not included in figure 3.

All Myanmar workers lived inside the factory. There were no significant differences between cases and non-cases with regard to age, gender, education, body mass index (BMI) and food or alcohol consumption (Table 1).

Study on Blood Thiamine Level

Epidemiological characteristics of 29 sampled workers were shown in table 2. Among 14 Myanmar workers sampled, one woman aged 38 years had thiamine deficiency and prevalence of thiamine deficiency among Myanmar workers was 7.1% (95% CI = 0-22.0). All 14 workers were Hindu and lived inside the factory.

Total 15 Thai workers sampled were Buddhists and lived in communities. Among them, four had thiamine deficiency and all were women, with median age of 54 years (range 45-65 years), and prevalence of thiamine deficiency of Thai workers was 26.7% (95% CI = 1.3-52.0). Median thiamine level of Thai was lower than that of Myanmar workers. However, the difference was not statistically significant (p-value = 0.29).

Environmental Survey

The Factory A was located in Phanom Sarakham District, Chachoengsao Province and was established in 2008. All Myanmar workers lived in small rooms surrounding the workplaces inside the factory while Thai workers lived in communities outside the factory. In the factory, Thai and Myanmar workers worked together in same production line.

From interview, workers reported higher workload during 2-3 months of the New Year period preceding

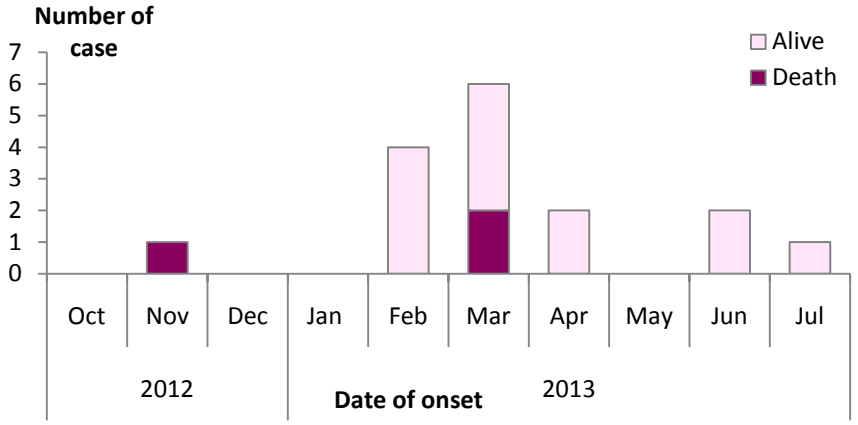

Figure 3. Suspect beriberi cases among Myanmar workers in Factory A, Thailand, November 2012 to July 2013 (n=16)

Table 1. Demographics, physical condition and consumption status of Myanmar workers in Factory A, Thailand, July 2013

Variable	Number of case (n=17)	Number of non-case (n=83)	Odds ratio (95% CI)	P-value
Median age (range)	26 years (20-30)	24 years (20-32)		0.46
Median year of education (range)	3.5 years (2.0-4.8)	4 years (2-6)		0.53
Gender (%)				
Male	13 (76.5)	50 (60.2)	2.1 (0.66-8.15)	
Female	4 (23.5)	33 (39.8)		
BMI (%)	*(n=13)*	*(n=83)*		
< 18.5	4 (30.8)	12 (14.5)	2.6 (0.50-11.35)	
≥ 18.5	9 (69.2)	71 (85.5)		
Median frequency of food consumption per week				
Chicken	3	3		0.72
Fermented fish	0	0		0.43
Bean	3	4		0.60
Betel nut	1	1		0.82
Tea or coffee	7	7		0.31
Alcohol consumption (%)	*(n=16)*	*(n=83)*		
Yes	3 (18.8)	14 (16.9)	1.1 (0.23-4.30)	
No	13 (81.3)	69 (83.1)		

Table 2. Epidemiological characteristics of workers tested for blood thiamine level in Factory A, Thailand, July 2013

Characteristic	Myanmar (n=14)	Thai (n=15)
Mean age in year (SD)*	28 (8)	47 (9)
BMI		
<18.5 (%)	2 (14.3)	0 (0)
18.5-25 (%)	10 (71.4)	10 (66.7)
≥25 (%)	2 (14.3)	5 (33.3)
Median thiamine level in nmol/L (IQR)	171 (145-213)	156 (114-196)
Median frequency of consuming thiamine-rich food weekly (range)		
Pork	0 (0,2)	3 (0,7)
Beef	0 (0,1)	0 (0,7)
Chicken	3 (1,5)	3 (0,7)
Bean	5 (1,7)	1 (0,7)
Median cost for food in Baht from November 2012 to July 2013 (range)	2,000 (1,500-6,000)	3,250 (2,000-6,000)
Number of person with alcohol consumption (%)	0	5 (33.3)
Number of person with inhalation of volatile glue (%)	3 (21.4)	7 (46.7)

** t-test, p-value <0.01*

the outbreak. Most of the Myanmar workers had no medical insurance while Thai workers had.

Most of Myanmar workers were young and had been working in Thailand for a few years. They went back to their hometowns during holidays or illness. They told that food in Myanmar was much cheaper than Thailand and they usually felt better after coming back from hometown. Myanmar workers usually bought food from the factory canteen or a mobile market nearby and prepared their meals at home. Both Myanmar workers and the canteen cooked food for a long time.

Milled white rice was the major portion of food consumed by both Thai and Myanmar workers. Common food sold in the canteen and the mobile market included vegetables, meat, eggs and fishes. Meals in the canteen were simple and consisted of roti (a type of flat bread which usually stuffed with boiled potato, vegetables, radish, cauliflower and/or paneer) and tea for breakfast, steamed rice with three food items (stir-fried vegetables, chicken with bean, potato soup and salad) for lunch, roti with tomato and tea for overtime workers in the evenings and steamed rice with 1-2 food items (stir-fried vegetables and vegetable soup) for dinner. Myanmar workers consumed similar recipes every week. All symptomatic cases were Hindu and abstained from eating meat three days per week.

Table 3. Thiamine levels of cooked food items in one day from canteen of Factory A, Thailand, 11 Jul 2013

Food item	Thiamine level (mg/100 gram)
Raw soybean	0.25
Roti	0.15
Stir-fried leave buds of rosella	0.13
Fried yard-long bean	0.10
Cabbage salad	0.08
Stir-fried bitter gourd	0.06
Stir-fried rosella	0.06
Stir-fried towel gourd	0.05
Tom yum soup	0.02

Cooked food items from the canteen were collected in July 2013 and tested for thiamine level (Table 3). Because we did not conduct the food consumption survey in this factory, we assumed that a worker ate 300 gram of rice and 100 gram of each food item per day. With the thiamine level of milled white rice as 0.08mg/100g[1], total thiamine intake calculated was 1.14 mg/person/day.

Discussion

We confirmed a cluster of beriberi among workers in Factory A during November 2012 to July 2013 in Chachoengsao Province of Thailand. Initial diagnosis for Myanmar hospitalized cases was done with no laboratory confirmation. Based on review from medical records of these cases, we found acute heart failure among young men while one of them recovered after receiving thiamine supplements. Additionally, laboratory results in our investigation showed seven cases with thiamine deficiency, including two cases identified from active case finding and five cases from blood thiamine study. Hence, although no history of death or beriberi case reported in this factory since 2008, existence of beriberi was confirmed in this factory after investigation.

Risk factors for thiamine deficiency were diet, body weight, physical activity, age, meal preparation and cooking, and anti-thiamine factors.[1] In this outbreak, thiamine deficiency might associate with risk factors such as poor diet, heavy physical activities and age. These risk factors were summarized in table 4.

Although our studies did not find any association with diet, results supported that this outbreak was related to dietary pattern: less meat dishes, high milled white rice and food with low thiamine. Workers consumed milled white rice, a high carbohydrate diet and also low thiamine level, which even led to more requirement of thiamine and caused thiamine deficiency. Moreover, the food processing of Myanmar workers reduced thiamine level in food due to long cooking time, which could lead to thiamine deficiency as well.

Besides, the investigation revealed effect of initial intervention on diet changes. The total thiamine intake that was in the RDA range of thiamine level for adults (1.1-1.2 mg daily)[1] showed that the first investigation had changed the workers' diet to rich thiamine foods such as soybean and affected total thiamine intake as well as the blood thiamine level among workers.

The second factor could be heavy physical activities due to high workload during previous months before the outbreak. This could explain suspect cases and deaths of Myanmar workers, especially from February to April 2013, based on low thiamine diet with heavy physical activities. This was also similar to a study about beriberi of Myanmar groups working in Thailand.[10]

The other factor could be the age. We found that prevalence of thiamine deficiency among older Thai

Table 4. Risk factors for thiamine deficiency among workers in Factory A, Thailand, July 2013

Risk factor	Reason
Diet	- Workers had few choices of food items because of their low salary.
	- Diets had poor thiamine, without meat, organ, poultry or whole grain rice.
	- Workers consumed high carbohydrate diet which led to higher requirement of thiamine.
Heavy physical activities	- They had higher workload during previous months before the outbreak
Medical condition	- Minimum requirements for dietary thiamine may increase with age, particularly for active individuals.[1]
	- Myanmar workers kept working until they had severe symptoms due to no health insurance.

women was higher than that of young Myanmar women. This was also compatible with a study by Oldham reported in WHO[1] that higher thiamine-calorie ratio was common for older people than young individuals.

The last factor was health insurance. As most of Myanmar workers had no medical insurance, they kept working until symptoms became severe and led to late diagnosis and treatment. With medical insurance of Thai workers from the Universal Coverage Scheme of Thailand[12,13], they might access to medical treatment even with mild symptoms. Thus, no severe case or death occurred among them although their prevalence of thiamine deficiency was higher than that of Myanmar workers.

Signs and symptoms of dry beriberi can vary a lot and are often difficult to be differentiated from other diseases. However, clinical symptoms and characteristics of hospitalized suspect cases in this outbreak suggested wet beriberi with leg edema and congestive heart failure. Hence, these signs and symptoms among young men could be a clue to look for thiamine deficiency in hospitals.

By combining rates of suspect cases and thiamine deficiency, we could assume high prevalence of thiamine deficiency among Myanmar and Thai workers in this factory. This might also suggest high prevalence of thiamine deficiency among Thai population in this region because of similar pattern of food consumption. These findings were also consistent with the Thai nutritional survey of construction and factory workers in 1996, which reported that those workers had high rates of biochemical, but not clinical, thiamine deficiency.[10] In addition, a survey on food consumption and nutrition in refugee camps along Thailand-Myanmar border from July to December 2003 found evidences of clinical and biochemical beriberi in all age groups (range 4.1-5.3 per 1,000 population).[10] Thus, further monitoring or enhancement of reporting system of beriberi was needed in this region.

Limitations

Because of time lapse between our investigation and beginning of the outbreak for about three months, Myanmar workers' diet had been changed as recommended by the first investigation team. This might explain why some symptomatic cases showed negative laboratory results and also cause information bias about signs and symptoms when we interviewed. Besides, with limited human resources and time, we could not conduct a dietary survey such as semi-quantitative food frequency or 24 hours recall for at least three days to be able to estimate and compare with RDA for thiamine.

Conclusion

There was a beriberi cluster among Myanmar workers in the factory. This outbreak was likely to be caused by long exposure to low thiamine food intake and heavy physical activities. The prevalence of thiamine deficiency among workers was high. Risk factors were likely to be poor diet and old age. Providing thiamine treatment and changing food items for thiamine rich diet stopped the outbreak.

Public Health Actions and Recommendations

We instructed factory workers how to identify symptoms of wet beriberi and provided health education about food with high level of B1.

Additionally, we recommended the hospitals for capacity building of clinicians on clinical diagnosis of cardiac beriberi and also providing effective health education on high level of B1 food to patients.

Finally, for the prevention and the improvement of the beriberi reporting system, we recommended

Provincial Health Office for monitoring of clinical manifestations of the factory workers and risk factors of thiamine deficiency.

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