

Characteristics and Laboratory Findings of Food-Induced Anaphylaxis in Children: Study in an Asian Developing Country

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Keywords

Anaphylaxis · Food hypersensitivity · Children · Tryptases · Allergy

Abstract

Introduction: Food allergy is the major cause of pediatric anaphylaxis. Characteristics and triggers may be different in different geographical regions. Studies focusing on food-induced anaphylaxis (FIA) in Asian developing countries are limited. Our study aimed to study characteristics of FIA in a tertiary care center in an Asian developing country. **Methods:** Retrospective review of pediatric anaphylaxis admission and outpatient visit at a tertiary care hospital in Bangkok, Thailand during 2008–2018 was performed. Data regarding clinical presentation, place reaction occurred, time of onset, investigations (serum tryptase, specific immunoglobulin E, and skin test), treatment, and follow-up periods were collected. **Results:** One hundred seventy-four anaphylaxis admission records of which 61 episodes of FIA were retrieved. Data from outpatients visit consisted of 17 patients. Most patients were male (76.7%). The median age was 7.1 years (interquartile range 1.9–12.4). The major causes of FIA were shrimp/shellfish (37%), wheat (15.1%), and cow's milk (11%). Food causing anaphylaxis varied according to age-group: infants had

anaphylactic reactions to egg, wheat, and cow's milk, pre-schools to wheat and peanut, and older children to shrimp/shellfish. Cutaneous manifestations occurred in all patients, followed by lower respiratory tract symptoms (83.6%) and gastrointestinal symptoms (50.8%). There was no biphasic anaphylaxis reported. Elevated serum tryptase was found in only 4 patients (7%). **Conclusion:** Recognizing characteristics of pediatric FIA is crucial. The common causes of FIA in our study in Asian children were egg in infants, wheat and peanut in preschool children, and shrimp/shellfish in school-age children and adolescents. Skin manifestation presented in all patients with FIA.

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Introduction

Anaphylaxis is a severe allergic reaction that is rapid in onset and potentially life-threatening [1]. The incidence of anaphylaxis is rising in Asia [2], Europe [3], and the United States [4]. Food is the most common cause of pe-

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diatric anaphylaxis [5, 6]. Food allergies appear to have increased over the past 3 decades, primarily in countries with a Western lifestyle [7]. Food-induced anaphylaxis (FIA) can be fatal [8]. In the United States, the major cause of fatal FIA was peanut in all age-groups, cow's milk in children, and tree nuts in adolescents and adults [9–11]. Unlike in Australia [12], where fatal FIA mostly occurred in adults, the major causes were shrimp/shellfish. In children, however, the reported culprit foods were peanut, tree nuts, cow's milk, and wheat.

In Thailand, the incidence rate of anaphylaxis in emergency department was 2.23 per 1,000 patients per year [13]. In pediatric patients, the incidence of anaphylaxis was increasing, from 2.67 to 4.51 cases per 1,000 pediatric admissions from 2004 to 2013 [14]. Prompt recognition and treatment are the key to reduce morbidity and mortality. However, the presentation of anaphylaxis in infants and children is different from adults, resulting in diagnostic challenges.

Several epidemiology studies of pediatric anaphylaxis in Asia were reported. Manuyakorn et al. [14] reported that the causes of anaphylaxis in Thai children were food (34.9%), drugs (33.1%), and blood components (23.8%). Similarly, in Korea, food was the leading cause of pediatric anaphylaxis (74.7%), followed by drugs and radiocontrast media (10.7%) and idiopathic (9.2%) [5]. The implicated food is regionally different. In Europe, peanut and tree nuts were the most frequent causes of FIA [6], consistent with the study in the United States [4]. Unlike in Asia, milk and egg were the predominant triggers in Japanese and Korean children [5, 15], whereas seafood and wheat were the major causes in Thailand [14], except in Singapore, peanut was the predominant trigger [16]. Studies of pediatric FIA in Asia reported heterogeneous causative foods, possibly due to different ethnic, culinary cultures, nurturing environment, and prevalence of atopic diseases.

Anaphylaxis is classically immunoglobulin E-mediated [1], causing mast cell activation and release of inflammatory mediators and cytokines. Additionally, anaphylaxis can result from other immunologic mechanisms such as IgG or complement, or nonimmunologic processes [17]. Serum tryptase, one of the mast cell mediators, from blood samples obtained within 15–180 min after symptom onset can be measured to support the clinical diagnosis of anaphylaxis [7]. However, in FIA, serum tryptase levels are rarely elevated [9]. Methods to improve sensitivity of serum tryptase in FIA were published, such as using elevated level and proportion compared with baseline value [18].

The aim of this study was to study the characteristics of FIA in Thai children in a tertiary care center, including causes, clinical manifestations, treatment, and to determine the role of sequential serum tryptase levels. The study will reflect perspectives of FIA from a developing Asian country.

Methods

A retrospective structured chart review was conducted at King Chulalongkorn Memorial Hospital (KCMH) for all patients younger than 18 years with diagnosis of FIA. The included patients admitted during January 2008 to April 2018 with International Classification of Diseases, 10th revision diagnostic codes: T78.0 (Anaphylactic reaction due to food), T78.1 (Other adverse food reactions, not elsewhere classified), T78.2 (Anaphylactic shock, unspecified), T78.3 (Angioneurotic edema), or T78.4 (Allergy, unspecified). Anaphylaxis was defined by the National Institute of Allergy and Infectious Disease and the Food Allergy and Anaphylaxis Network criteria [19]. Outpatients, visiting KCMH's pediatric allergy clinic during January 2017 and April 2018 with history of FIA at age <18 years were also included in this study.

King Chulalongkorn Memorial Hospital, a tertiary care hospital, is in the urban area of Bangkok, and one of the largest allergy referral centers of pediatric allergy patients in the country. All pediatric patients presented with anaphylaxis at the emergency room were admitted for observation, according to hospital protocols. Therefore, the inpatient records could represent the target group.

The medical records were reviewed and obtained demographic characteristics, including history of atopic diseases, and history of allergy. Clinical features were classified as cutaneous, respiratory, cardiovascular, gastrointestinal, and ocular systems. The triggers of the episodes were determined by allergy specialists. The location of occurrence, route of exposure, time to symptom onset, investigations: serum tryptase, specific immunoglobulin E (SIgE), and skin test results were collected. Treatment, length of hospital stays, and follow-up data: follow-up time, number of anaphylaxis episodes after discharge, and also current status were evaluated. The referral patients' age at events, sex, race, and triggers were also collected, though history of atopic disease was not included in the analysis due to unknown temporal relationship with anaphylactic events.

Skin prick test (SPT) was performed at least 4 weeks after anaphylactic event, with histamine 1 mg/mL as positive control and normal saline as negative control. The result of SPT was recorded as mean wheal diameter in millimeters. SIgE to food was measured using ImmunoCAP (Thermo Fisher Scientific, Uppsala, Sweden). Any SIgE values reported as >100-kilo units of allergen per liter (kUA/L) were analyzed as 100 kUA/L.

Statistical analysis was performed using Stata version 16.0. The age of patients, laboratory data, and other continuous data were described using median (interquartile range [IQR]), whereas the nominal data using percentage. Comparing between groups was determined using either independent *t* test, dependent *t* test, 1-way ANOVA, Mann-Whitney U test, Kruskal Wallis test, χ^2 test, or Fisher's exact test, as appropriate. *p* values <0.05 were considered to be statistically significant. The Institutional Review Board of Faculty of Medicine, Chulalongkorn University approved the study (IRB No. 733/60).

Table 1. Baseline characteristics of pediatric inpatients, referral patients and all patients with FIA

Characteristics	Inpatients, <i>n</i> (%)	Referral patients, <i>n</i> (%)	All, <i>n</i> (%)
Total	56	17	73
Gender: male	44 (78.6)	12 (70.6)	56 (76.7)
Age (median, IQR, years)	9, 4.7–13	0.7, 0.5–3.5	7.1, 1.9–12.4
<1 year	4 (7.1)	9 (52.9)	13 (17.8)
1–5 years	10 (17.9)	7 (41.2)	17 (23.3)
6–10 years	17 (30.4)	1 (5.9)	18 (24.7)
11–18 years	25 (44.6)	–	25 (34.2)
Nationality			
Thai	52 (92.9)	16 (94.1)	68 (93.2)
Asian (non-Thai)	2 (3.6)	–	2 (2.7)
Caucasian	2 (3.6)	1 (5.9)	3 (4.1)
Past history of atopic disease	31 (55.4)	17 (100)	48 (65.8)
Allergic rhinitis	8 (14.3)	1 (5.9)	9 (12.3)
Asthma	3 (5.4)	–	3 (4.1)
Atopic dermatitis	5 (8.9)	3 (17.7)	8 (11)
Previous food allergy	30 (54)	17 (100)	45 (61.6)
History of drug allergy	7 (12.5)	1 (5.9)	8 (11)
History of inhalant allergy [†]	3 (3.4)	3 (17.7)	6 (8.2)

IQR, interquartile range; FIA, food-induced anaphylaxis. [†] History of inhalant allergy defined by positive skin test to any aeroallergens.

Results

Overview and Baseline Characteristics

During January 2008 to April 2018, 174 pediatric inpatient records registered with International Classification of Diseases, 10th revision of T78.0 – T78.4, out of these, 61 records of 56 patients had FIA. Anaphylactic admission occurred 4 times in one patient and 2 times in 2 patients with the same allergens, therefore only the first records of these patients were included. The trends of FIA events were increasing from 2 to 6 episodes per year in 2008–2015 to 8–11 episodes per year in 2016–2017, consistent with in 2018, there were 9 episodes in 4-month period. Seventeen outpatients with history of FIA were also included in this study.

Table 1 showed the baseline characteristics. The majority of the subjects were male (76.7%). The median age (IQR) was 7.1 years (1.9–12.4). Overall, 13 (17.8%) were infants (<1 year), 17 (23.3%) were preschool children (1–5 years), 18 (24.7%) were school-age children (6–10 years), and 25 (34.2%) were adolescents (11–18 years). Most patients were Thai (93.2%), while 3 were Caucasian. Past histories of atopic diseases, allergic rhinitis, asthma, atopic dermatitis, and previous food allergy were present in 48 (65.8%), 9 (12.3%), 3 (4.1%), 8 (11%), and 45 (61.6%),

respectively. Atopic dermatitis was the only significant factor associated with FIA in children under 5 years of age, OR 16.4 (95% CI 1.4–826.4, *p* 0.003). Almost half of the children with FIA in our study developed reactions to food they previously tolerated (26, 46%). Anaphylaxis on the first exposure occurred in 7 patients; 2 patients were infants with atopic dermatitis who had egg and wheat allergy, 1 patient was preschool child with wheat allergy, and 4 patients were school-age children with fried insect allergy.

Triggers of FIA

The most common trigger of FIA in our population was shrimp/shellfish (37%), followed by wheat (15.1%), cow's milk (11%), egg (9.6%), and fried insect (6.8%), as shown in Figure 1. Among the fried insect-triggered FIA, 3 patients reacted to pupae, one to grasshopper, and the other to aquatic beetle *Cybister limbatus*. Fried insect was the distinct cause of anaphylaxis in Thailand, where many types of fried insect were consumed as snack. Shrimp/shellfish triggered FIA at significantly different ages (median age 12.4 years, IQR 8.8–14.9, *p* < 0.001), as well as egg (median age 0.5 year, IQR 0.3–1.3, *p* < 0.001) and wheat (median age 1.7 years, IQR 0.6–4, *p* 0.015). Considering each age-group, egg, wheat, and

Fig. 1. Causes of pediatric inpatient and referral cases with history of FIA, by age-group. FIA, food-induced anaphylaxis.
^oFisher's exact; * $p < 0.05$.

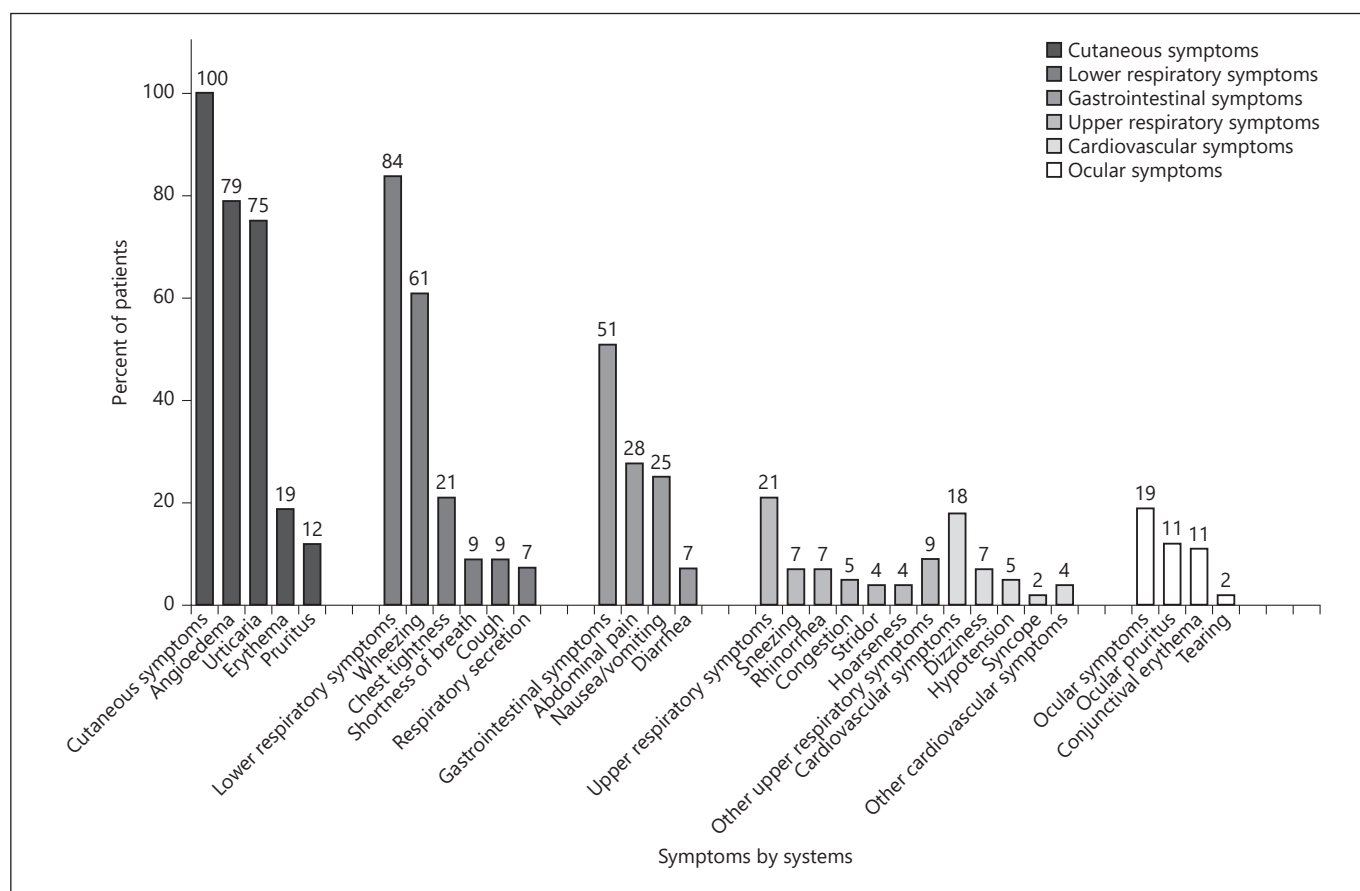
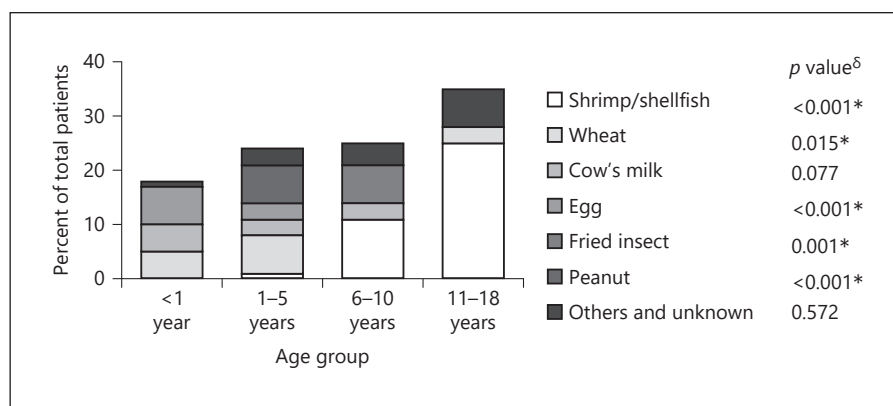


Fig. 2. Clinical features of pediatric inpatients with FIA by systems. FIA, food-induced anaphylaxis.

cow's milk were the major causes in infants, meanwhile in adolescents, shrimp/shellfish was the dominant cause. Oral mite anaphylaxis was suspected in 2 patients, age 6.8 and 12.4 years old, who had anaphylaxis after eating fried chicken made from improperly stored wheat with confirmatory test supporting the diagnosis.

Four children (5.5%) had unknown cause of anaphylaxis.

Clinical Features of FIA

Clinical features of FIA were determined in inpatients group. The results were classified into 6 systems: cutane-

Table 2. Clinical manifestations and associated allergic diseases of pediatric inpatients with FIA according to age-group

Clinical manifestations	N (% of inpatients)			p value ^δ
	all age-groups	<5 years	5–18 years	
Atopic dermatitis	5 (8.9)	4 (7.1)	1 (1.8)	0.012*
Allergic rhinitis	8 (14.3)	1 (1.8)	7 (12.5)	0.664
Asthma	3 (5.4)	1 (1.8)	2 (3.6)	1.000
History of food allergy	28 (50)	7 (12.5)	21 (37.5)	1.000
Cutaneous symptoms	56 (100)	42 (75)	14 (25)	–
Angioedema	44 (78.6)	9 (16.1)	35 (62.5)	0.151
Urticaria	42 (75)	9 (16.1)	33 (58.9)	0.304
Erythema	10 (17.9)	3 (5.4)	7 (12.5)	0.698
Pruritus	7 (12.5)	2 (3.6)	5 (8.9)	1.000
Lower respiratory symptoms	47 (83.9)	10 (17.9)	37 (66.1)	0.206
Wheezing	34 (60.7)	9 (16.1)	25 (44.6)	1.000
Chest tightness	12 (21.4)	–	12 (21.4)	0.026*
Shortness of breath	5 (8.9)	–	5 (8.9)	0.316
Cough	5 (8.9)	1 (1.8)	4 (7.1)	1.000
Respiratory secretion	3 (5.4)	3 (5.4)	–	0.013*
Gastrointestinal symptoms	29 (51.8)	6 (10.7)	23 (41.1)	0.542
Abdominal pain	16 (28.6)	–	16 (28.6)	0.005*
Nausea/vomiting	14 (25)	6 (10.7)	8 (14.3)	0.089
Diarrhea	4 (7.1)	–	4 (7.1)	0.562
Upper respiratory symptoms	12 (21.4)	2 (3.6)	10 (17.9)	0.709
Sneezing	4 (7.1)	1 (1.8)	3 (5.4)	1.000
Rhinorrhea	4 (7.1)	–	4 (7.1)	0.562
Nasal congestion	3 (5.4)	–	3 (5.4)	0.565
Stridor	2 (3.6)	1 (1.8)	1 (1.8)	0.441
Hoarseness	2 (3.6)	–	2 (3.6)	1.000
Cardiovascular symptoms	10 (17.9)	4 (7.1)	6 (10.7)	0.247
Dizziness	4 (7.1)	–	4 (7.1)	0.562
Hypotension	3 (5.4)	1 (1.8)	2 (3.6)	1.000
Syncope	1 (1.8)	1 (1.8)	–	0.250
Ocular symptoms	11 (19.6)	–	11 (19.6)	0.049*
Ocular pruritus	6 (10.7)	–	6 (10.7)	0.319
Conjunctival erythema	6 (10.7)	–	6 (10.7)	0.319
Tearing	1 (1.8)	–	1 (1.8)	1.000

FIA, food-induced anaphylaxis, ^δ Fisher's exact, * $p < 0.05$.

ous, upper respiratory, lower respiratory, cardiovascular, gastrointestinal, and ocular systems, as shown in Table 2; Figure 2. All of the patients had cutaneous symptoms, for example, angioedema (78.6%) and urticaria (75%), followed by lower respiratory symptoms (83.9%), for example, wheezing (60.7%), and chest tightness (21.4%). Hypotension occurred in 5.4%. Gastrointestinal system was affected in half of the patients, for example, abdominal pain (28.6%) and nausea/vomiting (25%). Upper respiratory and ocular systems were involved in 21.4 and 19.6%. School-age children and adolescents tended to have more abdominal pain, chest tightness, and ocular

symptoms, while young children tended to have respiratory secretion.

Other Features of FIA

Table 3 showed other features of anaphylactic episodes. Anaphylaxis severity, grading according to Brown's severity scoring [20], the children were mainly categorized as grade 2 (80.4%), followed by grade 3 (17.9%), and grade 1 (1.8%). There had been no fatal case. The first presenting symptoms were cutaneous (62.5%), gastrointestinal (17.9%), lower respiratory tract (16.1%), and ocular symptoms (3.6%). Almost all patients developed ana-

Table 3. Features of pediatric inpatients with FIA

Features	N (% of total patients)
Severity grading [†]	
Grade 1	1 (1.8)
Grade 2	45 (80.4)
Grade 3	10 (17.9)
Initial presenting symptom	
Cutaneous symptoms	35 (62.5)
Urticaria	20 (35.7)
Angioedema	11 (19.6)
Erythema	2 (3.6)
Pruritus	2 (3.6)
Gastrointestinal symptoms	10 (17.9)
Abdominal pain	6 (10.7)
Vomiting	3 (5.4)
Diarrhea	1 (1.8)
Respiratory symptoms	9 (16.1)
Wheezing	6 (10.7)
Chest tightness	3 (5.4)
Ocular symptoms	2 (3.6)
Eye pruritus	2 (3.6)
Route of exposure	
Ingestion	55 (98.2)
SPT	1 (1.8)
Place of occurrence	
Home	12 (21.4)
School	4 (7.1)
Hospital	3 (5.4)
Mall/market	3 (5.4)
Other public places	2 (3.6)
Not defined	32 (57.1)
Time to onset of symptom after ingestion, median, IQR (min)	30, 15–60
Amount of food ingested, median, IQR (grams) (<i>n</i> = 23)	30, 20–100
Time to hospital, median, IQR (hours)	1, 0.5–1.8
Follow-up	
Follow-up after discharge	36 (64.3)
Follow-up time, median, IQR (days)	55, 0–428
Episodes of anaphylaxis after discharge	
1 episode	6 (10.7)
2 episodes	1 (1.8)
3 episodes	1 (1.8)
Current status	
Outgrown	1 (1.8)
Anaphylaxis	8 (14.3)
No further exposure of allergen	28 (50.0)

IQR, interquartile range; FIA, food-induced anaphylaxis; SPT, skin prick test. [†]From Brown SG. Clinical features and severity grading of anaphylaxis. *J Allergy Clin Immunol.* 2004;114:371–6.

phylactic events by ingestion (98.2%). However, 2 subjects had reactions after SPT to egg. One subject had previous history of egg-induced urticaria, another one had a history of egg-induced anaphylaxis. The places of allergen exposure were home (21.4%), school (7.1%),

mall/market (5.4%), and not defined in half of the patients. The median time to onset of anaphylaxis after food exposure was 30 minutes (IQR 15–60). The median amount of food ingested was 30 grams (IQR 20–100). The median time to hospital was 1 hour (IQR 0.5–1.8).

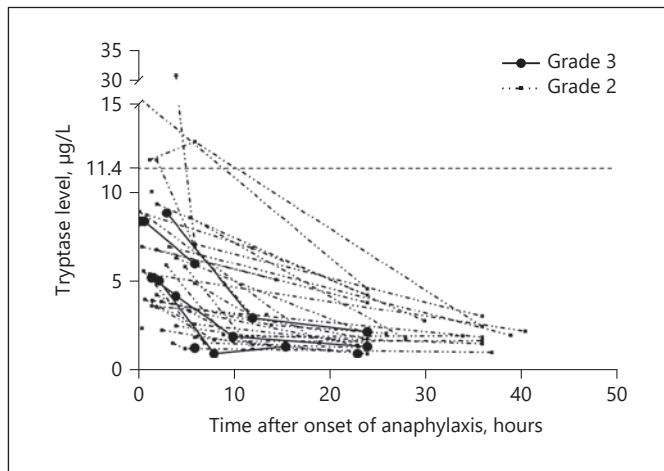


Fig. 3. Plot of serum tryptase level over time after symptom onset of pediatric inpatients with FIA, by severity grading. FIA, food-induced anaphylaxis.

Recurrent Anaphylaxis

Ten children (17.9%) had recurrent episodes of anaphylaxis. The reasons in the preschoolers were incomplete labeling of the allergen, and accidental ingestion. Meanwhile, some of the adolescents had recurrent anaphylaxis with intended ingestion with certain precautionary measures, such as taking antihistamines before the ingestion or taking small amount of the food.

Treatment of FIA

Almost all of the patients were treated with adrenaline (98.2%), H1 antihistamine (54%), and corticosteroids (100%). The adrenaline was not administered to 1 patient due to the incorrect initial diagnosis of the episode as asthmatic attack. Bronchodilator was administered in 35 episodes (62.5%), and H2 antihistamine in 17 episodes (30.4%). Biphasic anaphylaxis was defined as symptoms recur within 1–72 hours (usually within 8–10 hours) after the initial symptoms had resolved, despite no further exposure to the trigger [19]. None of the subjects experienced biphasic reaction in this study. The median length of hospital stay was 1 day (IQR 1–2). Adrenaline auto-injector or prefilled injections was prescribed in 40 admissions (71.4%) at discharge.

Investigations

Figure 3 showed plot of serum tryptase level and time after symptom onset. According to manufacturer's manual, elevated serum tryptase is $>11.4 \mu\text{g/L}$ (95th percentile of healthy individuals). By this definition, only 4 patients (12.5%) had elevated serum tryptase, with median of $14 \mu\text{g/L}$ (IQR 12.4–22.9, range 11.9–30.8), and median time

after onset of symptom of 3 hours (IQR 1.5–5, range 1–6). Nevertheless, the elevated tryptases were not correlated with anaphylaxis severity, since 2 patients (100%) of grade 3 severity failed to demonstrate the rises.

Baseline serum tryptase, from sample collected >24 hours after anaphylaxis episodes, was measured in 22 patients (39.3%). The median baseline serum tryptase was $2 \mu\text{g/L}$ (IQR 1.6–2.5, range 1–4.6). The median difference of peak and baseline serum tryptase was $4.1 \mu\text{g/L}$ (IQR 2.2–6.6). Using Sprung et al. [21] proposed cutoff value with acute level >2 plus 1.2 times baseline tryptase level, 16 out of 22 patients (72.7%) had elevated serum tryptase at 0.67–6 hours after onset of symptoms.

SIgE to foods and aeroallergens was tested in 36 cases (64.3%). The highest SIgE was to cow's milk, followed by wheat and egg white with the results of 74.2 kUA/L (IQR 27.5–100 kUA/L, from 4 patients), 7.4 kUA/L (IQR 6.7–100 kUA/L, from 5 patients), and 5.9 kUA/L (IQR 1.1–49 kUA/L, from 3 patients), respectively. In shrimp/shellfish anaphylaxis, the SIgE was as low as 4 kUA/L , IQR 0.9–11.6 kUA/L, tested in 17 patients. SIgE to house dust mite was tested in 2 admissions, showed 5.4 kUA/L , range 2.7–8.1 kUA/L. Fish SIgE in only 1 episode showed 2.6 kUA/L .

SPT was done in 19 patients (33.9%). SPT to shrimp/shellfish was done in 10 patients. The result was 8.5 mm , IQR 6–10 mm. Wheat SPT in 3 patients showed 11 mm , range 10–13 mm. SPT to egg white, cow's milk, fish, banana, house dust mite, and fried insect (fried pupae in packaged food of unidentified species of insect) were done in 1 patient for each food, and the results were 3, 6, 10, 5, 9, and 7 mm, respectively.

Follow-up

After discharge, as shown in Table 3, the follow-up rate was 64.3%, with the median follow-up time of 55 days (IQR 0–428). Oral food challenge test to confirm the diagnosis and to find safe alternatives, such as different kinds of shellfish, was done in 4 patients (7.1%). Seven patients (12.5%) still experienced anaphylaxis after discharge. Most patients (80.4%) had never been exposed to allergen after the events.

Discussion

Our study provided a comprehensive aspect of pediatric FIA in the context of a tertiary care center in an Asian developing country. The causes of FIA were similar among Asian countries [5, 15], very young children had reactions to cow's milk, egg, and wheat while the older

children to shellfish. In contrast, Western studies [4, 6] showed that peanut and tree nuts were the major implicated foods in all age-groups.

Regarding pediatric anaphylaxis, the large study in Korea by Lee et al. [5] found that anaphylaxis in children mostly caused by food, accordant with the previous study in Thailand. Manuyakorn et al. [14] reported the majority of all causes of pediatric anaphylaxis caused by food, for example, seafood, wheat, and cow's milk.

We found that atopic dermatitis was the significant factor associated with FIA in children under 5 years with OR 16.4 (95% CI 1.4–826.4, p 0.003). Importantly, about half of children with atopic dermatitis who had FIA developed anaphylaxis with their first ingestion of culprit foods, suggesting that skin barrier defects might involve in food sensitization [22]. Our findings support the APAPARI statements [23] that infants with severe eczema who could access to allergy expertise should have food allergy testing and supervised oral challenge if sensitized. Four school-age children reacted to fried insects in their first ingestion. The underlying explanation could be the cross-reactivity between crustaceans/house dust mite and edible insects, as shown in the previous report [24].

Interestingly, our series found that clinical features of FIA were varied. Cutaneous symptoms were consistently found in all patients and simple to detect. Some of the symptoms were inconsistent depending on the age-group, additionally ocular symptoms should be observed. Recurrent anaphylaxis was found in almost 1 out of 5 cases of anaphylaxis (18%), especially in preschool and teenage children, emphasizing the preventive measures such as product allergen labeling and patient education.

Baseline serum tryptase level in pediatric patients with FIA in this study was lower than expected, comparing to the findings by Sahiner et al. [25]. Further study with comparing group and more subjects is needed to address this question. Sensitivity of serum tryptase in diagnosing FIA was 12.5% when using 11.4 $\mu\text{g/L}$ as cutoff value. This increased to 72.7% when baseline serum tryptase was used for calculation (2 plus 1.2 times baseline tryptase level) [21], corresponded with the previous study [26]. The disadvantage of this approach is the need to measure the baseline value; more studies were needed to find the specificity. Our findings suggested that serum tryptase measurement may be useful in aiding the diagnosis of FIA when both acute level and basal level are measured.

Anaphylaxis is the life-threatening condition [8], thus identifying the causative foods is crucial. Despite this significance, only 36 children (64.3%) in this study attended the follow-up visits. This indicates the overlook of this

potentially fatal condition. Therefore, patients' and/or parents' education, emphasizing allergens avoidance, emergency plan, and follow-up for re-testing and re-evaluation should be implemented since the initial episodes.

Conclusion

The most common causes of Thai pediatric FIA in our tertiary care center were egg in infants, wheat and peanut in preschool children, and shrimp/shellfish in school-age children and adolescents. All children with FIA manifested cutaneous symptoms. Clinical application of serum tryptase elevation required future controlled studies. Awareness to the conditions and cause identifying are crucial to save patients.

Statement of Ethics

The Institutional Review Board of Faculty of Medicine, Chulalongkorn University approved the study protocol (IRB No. 733/60). Due to retrospective design and anonymous data collection, informed consents were not required.

Conflict of Interest Statement

The authors have declared no conflicts regarding this manuscript.

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Author Contributions

R.N. contributed on writing the first draft of the manuscript, data collection, and data analysis. P.C. was the principal investigator of this study. P.C. and N.S. designed the study and contributed on writing the manuscript and taking care overall of this work. All the authors approved the final version of this paper.

Data Availability Statement

The data availability of this article might compromise the privacy of the participants.

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