



Assessment of ED triage of anaphylaxis patients based on the Emergency Severity Index

Daniel Chiang, MD^a, Justine M. Ade, MD^b, Xiao-wei Liu, MD^{a,c}, Fernanda Bellolio, MD, MS^a, Christine M. Lohse, MS^d, Benjamin J. Sandefur, MD^a, Ronna L. Campbell, M.D., Ph.D.^{a,*}

^a Department of Emergency Medicine, Mayo Clinic, Rochester, MN, United States of America

^b Division of Allergic Diseases, Mayo Clinic, Rochester, MN, United States of America

^c Department of Emergency Medicine, The First Affiliated Hospital of China Medical University, Liaoning, Shenyang, China

^d Department of Health Sciences Research, Mayo Clinic, Rochester, MN, United States of America

ARTICLE INFO

Article history:

Received 20 July 2020

Received in revised form 7 October 2020

Accepted 25 October 2020

Keywords:

Anaphylaxis

Emergency department

Epinephrine

Triage

ABSTRACT

Objectives: To describe the emergency department (ED) triage of anaphylaxis patients based on the Emergency Severity Index (ESI), assess the association between ESI triage level and ED epinephrine administration, and determine characteristics associated with lower acuity triage ESI assignment (levels 3 and 4).

Methods: We conducted a cohort study of adult and pediatric anaphylaxis patients between September 2010 and September 2018 at an academic ED. Patient characteristics and management were compared between Emergency Severity Index (ESI) triage level 1 or 2 versus levels 3 or 4 using logistic regression analysis. We adhered to STROBE reporting guidelines.

Results: A total of 1090 patient visits were included. There were 26 (2%), 515 (47%), 489 (45%), and 60 (6%) visits that were assigned an ESI triage level of 1, 2, 3, and 4, respectively. Epinephrine was administered in the ED to 53% of patients triaged ESI level 1 or 2 and to 40% of patients triaged ESI level 3 or 4. Patients who were assigned a lower acuity ESI level of 3 or 4 had a longer median time from ED arrival to epinephrine administration compared to those with a higher acuity ESI level of 1 or 2 (28 min compared to 13 min, $p < .001$). A lower acuity ESI level was more likely to be assigned to visits with a chief concern of hives, rash, or pruritus (OR 2.33 [95% CI, 1.20–4.53]) and less likely to be assigned to visits among adults (OR, 0.43 [0.31–0.60]), patients who received epinephrine from emergency medical services (OR 0.56 [0.38–0.82]), presented with posterior pharyngeal or uvular angioedema (OR, 0.56 [0.38–0.82]), hypoxemia (OR, 0.34 [0.18–0.64]), or increased heart (OR 0.83 [0.73–0.95]) or respiratory (OR 0.70 [0.60–0.82]) rates.

Conclusion: Patients triaged to lower acuity ESI levels experienced delays in ED epinephrine administration. Adult and pediatric patients with skin-related chief concerns were more likely to be assigned lower acuity ESI levels. Further studies are needed to identify interventions that will improve ED anaphylaxis triage.

© 2020 Elsevier Inc. All rights reserved.

1. Introduction

1.1. Background

Anaphylaxis is a potentially life-threatening allergic reaction [1,2]. Although some anaphylactic reactions may be mild, the risk of progression to severe anaphylaxis makes early recognition and treatment with epinephrine imperative [1]. The rapid identification of anaphylaxis in emergency department (ED) patients starts in triage, making prompt and accurate triage crucial in order to initiate effective life-saving therapy.

A recent pediatric cohort study reported that the majority of pediatric anaphylaxis cases were under-triaged based on the Canadian Pediatric Emergency Triage and Acuity Scale (PaedCTAS) [3]. However, there are no studies describing the accuracy of ED triage in adult anaphylaxis or evaluating anaphylaxis triage using the Emergency Severity Index (ESI).

The ESI is the most widely used triage scoring system among EDs in the United States [4]. It is a validated five level system associated with ED resource utilization and patient admission in both adult and pediatric patients and associated with patient mortality in adults [5–7]. ESI assignment is based on a patients' need for immediate or urgent intervention, vital signs, and expected resource utilization [8]. Based on ESI, the highest acuity patients who require immediate life-saving interventions are triaged level 1. High-risk, acutely confused, or distressed patients are triaged as level 2. High-risk patients are defined as patients

* Corresponding author at: Department of Emergency Medicine, Mayo Clinic, 200 First St SW, Rochester, MN 55905, United States of America.

E-mail address: campbell.ronna@mayo.edu (R.L. Campbell).

who may require time-sensitive treatment or who have a condition that could easily deteriorate. The lower acuity ESI levels 3 through 5 are based on anticipated resource need with possible elevation to level 2 based on vital signs.

Research on the accuracy of ED triage for anaphylaxis is limited. Our aim was to describe the ED triage of adult and pediatric anaphylaxis patients based on the ESI, assess the association between ESI triage level and ED epinephrine administration, and determine characteristics associated with lower acuity triage ESI assignment (levels 3 and 4).

2. Methods

2.1. Study design and setting

We conducted an observational cohort study of prospectively and retrospectively enrolled patients between September 2010 and September 2018 at Mayo Clinic Hospital, Saint Mary's Campus, Rochester, Minnesota, a quaternary care academic ED with 77,000 annual patient visits. The IRB approved the study protocol. Our study adheres to the STROBE (Strengthening the Reporting of Observational studies in Epidemiology) guidelines for reporting observational studies [9].

2.2. Participant selection

We included patients of all ages if they had granted permission for review of their medical records (retrospective cohort) or if the patients or caregivers provided informed consent for use of medical records for research purposes (prospective cohort). Patient enrollment and data collection procedures were previously described [10]. Abstractors were trained using a standardized protocol and approximately 15% of charts were double extracted by a senior investigator to ensure reliable data extraction. Patients who experienced anaphylaxis secondary to an intervention that occurred after arrival to the ED were excluded.

We identified patients retrospectively if their ED diagnosis included the text “anaph-,” “allerg-,” or “sting”. Prospectively, we identified patients if their chief concern included “allerg-,” “reaction,” “anaphy-,” “angio-,” “sting,” “hives,” or “rash,” as determined by the triage nurse. Study coordinators then confirmed with the ED providers the suspicion for allergic reaction or anaphylaxis.

2.3. Case definition

We included patients if they met the National Institute of Allergy and Infectious Diseases (NIAID) and Food Allergy and Anaphylaxis Network (FAAN) criteria for anaphylaxis [11]. Per the criteria, anaphylaxis is highly likely when any one of the following 3 criteria are fulfilled (used with permission):

1. Acute onset of an illness (minutes to several hours) with involvement of the skin, mucosal tissue, or both (e.g., generalized hives, pruritus or flushing, swollen lips-tongue-uvula)
And at least one of the following.
 - a. Respiratory compromise (e.g., dyspnea, wheeze-bronchospasm, stridor, reduced peak expiratory flow, hypoxemia).
 - b. Reduced blood pressure (BP) or associated symptoms of end-organ dysfunction (e.g., hypotonia [collapse], syncope, incontinence).
2. Two or more of the following that occur rapidly after exposure to a likely allergen for that patient (minutes to several hours):
 - a. Involvement of the skin-mucosal tissue (e.g., generalized hives, itch-flush, swollen lips-tongue-uvula).
 - b. Respiratory compromise (e.g., dyspnea, wheeze-bronchospasm, stridor, reduced peak expiratory flow, hypoxemia).
 - c. Reduced BP or associated symptoms (e.g., hypotonia [collapse], syncope, incontinence).

- d. Persistent gastrointestinal symptoms (e.g., crampy abdominal pain, vomiting).

3. Reduced BP after exposure to known allergen for that patient (minutes to several hours):

- a. Infants and children: low systolic BP (defined as less than 70 mmHg from 1 month to 1 year, less than $(70 \text{ mmHg} + [2 \times \text{age}])$ from 1 to 10 years, and less than 90 mmHg from 11 to 17 years) or greater than 30% decrease in systolic BP.
- b. Adults: systolic BP of less than 90 mmHg or greater than 30% decrease from that person's baseline.

2.4. Variables and outcome measures

Our primary outcome of interest was triage ESI level with a comparison of patients with ESI level of 1 or 2 versus ESI level of 3 or 4.

Electronic medical record data including patient demographics, allergic history, presenting signs and symptoms, anaphylaxis management, and disposition were extracted. For prospectively enrolled patients, we obtained data on allergic history, presenting signs and symptoms, and prehospital management from the patients or caregivers. ED providers also completed questionnaires. Data were entered into an electronic study data management system that was programmed to automatically determine if NIAID/FAAN criteria were met based on the reaction onset, allergen exposure, and presenting signs and symptoms.

2.5. Statistical methods

Continuous features were summarized with means and standard deviations (SDs) when approximately normally distributed and with medians and interquartile ranges (IQRs) otherwise. Categorical features were summarized with frequency counts and percentages. Features were compared by ESI (1/2 versus 3/4) using two-sample t, Wilcoxon rank sum, chi-square, and Fisher exact tests based on the type and distribution of the feature under study. A multivariable model was developed by examining all subsets of candidate predictors and choosing the model that maximized the likelihood score statistic, minimized the Akaike information criteria, and included predictors that were statistically significantly associated with ESI. Candidate predictors included patient demographics, suspected allergen, allergic history, vital signs, presenting signs and symptoms, chief concerns, and prehospital epinephrine administration. Systolic blood pressure, diastolic blood pressure, mean arterial pressure, and SpO2 were not considered in the multivariable model building because of the amount of missing data for these features. Instead, once a multivariable model was chosen, these features were added, one at a time, to determine if they contributed statistically significant information to predict ESI. Statistical analyses were performed using SAS version 9.4 (SAS Institute; Cary, NC). All tests were two-sided and p -values $< .05$ were considered statistically significant.

3. Results

3.1. Participant enrollment

A total of 1408 visits between September 19, 2010 and September 14, 2018 were identified including 916 retrospective visits and 492 prospective visits. After exclusion criteria were applied, there were a total of 1090 visits among 970 distinct patients eligible for study inclusion. A flowchart of patient enrollment is shown in Fig. 1.

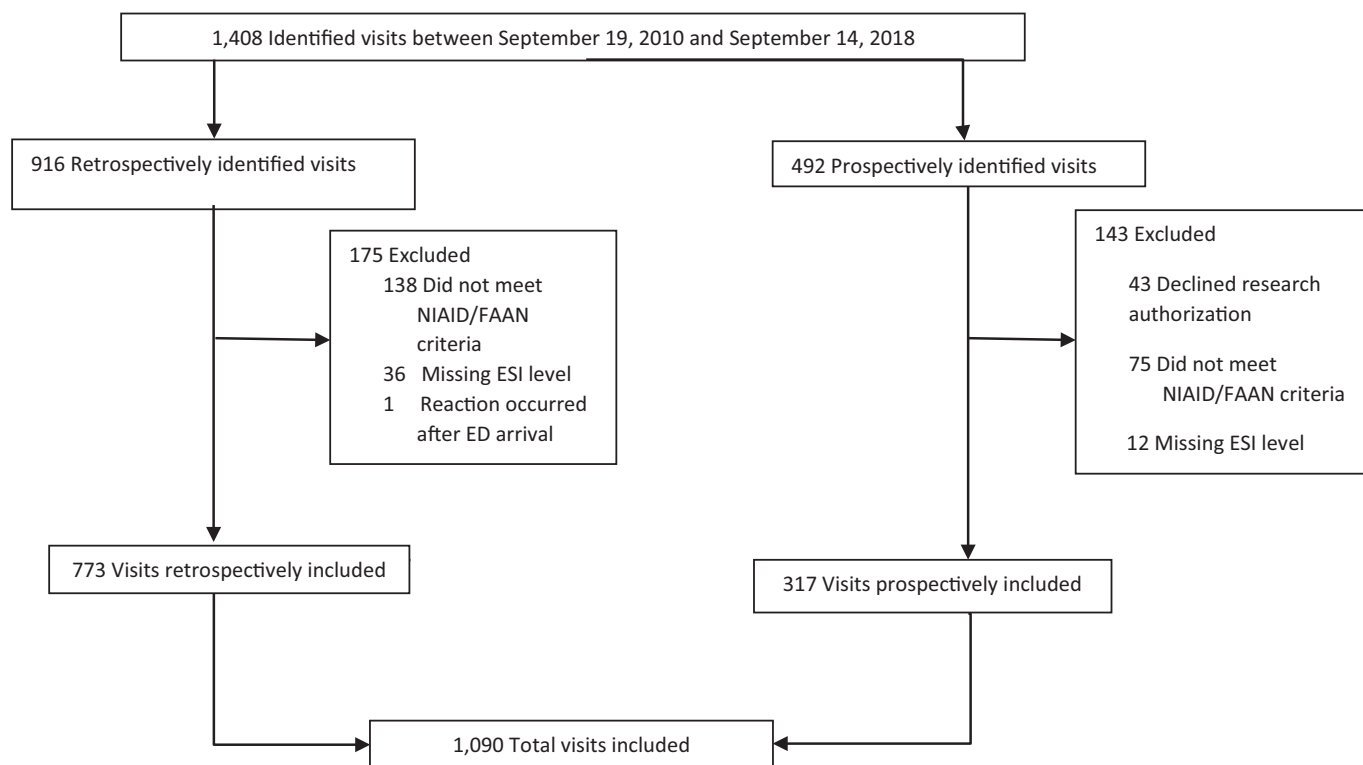


Fig. 1. Flowchart of patient enrollment. NIAID/FAAN; National Institute of Allergy and Infectious Diseases (NIAID) and the Food Allergy and Anaphylaxis Network (FAAN) criteria; ESI, Emergency Severity Index; ED; Emergency Department.

3.2. Characteristics of study participants

The mean age of the cohort was 33.7 years. There was a total of 309 (28%) visits among pediatric patients (age < 18 years) and 626 (57%) visits were made by female patients. Among visits with an identified suspected allergen, food was the most common inciting allergen (404 visits [37%]), followed by medications (182 [17%]), and venom (166 [15%]). Most visits were associated with mucocutaneous (1066 [98%]) and respiratory (908 [83%]) presenting signs and symptoms, as well as angioedema (646 [59%]). Among all encounters, epinephrine was administered prior to ED arrival in 324 (30%) cases, and epinephrine was administered in the ED in 503 (46%) cases. Overall, a total of 780 (72%) patients received epinephrine either prior to ED arrival or in the ED or ED observation unit.

3.3. Triage ESI level assignment

Of the 1090 total visits included in the study, there were 26 (2%), 515 (47%), 489 (45%), and 60 (6%) visits that were assigned a triage ESI level of 1, 2, 3, and 4, respectively. There were no visits assigned to an ESI level of 5. Among 781 visits by adult patients, 412 (53%) were leveled ESI 1 or 2, and among 309 visits by pediatric patients, 129 (42%) were leveled ESI 1 or 2.

3.4. Univariable analysis of factors associated with triage ESI level

Table 1 demonstrates univariable characteristics associated with visits assigned lower acuity ESI levels (ESI 3 or 4) versus higher acuity ESI levels (ESI 1 or 2). There were no significant differences in sex,

Table 1
Univariable associations between higher acuity ESI and lower acuity ESI groups

Feature	All visits (N = 1090)	Higher acuity ESI (Level 1 or 2) (N = 541)	Lower acuity ESI (Level 3 or 4) (N = 549)	P value
Age at visit, mean (SD)	33.7 (22.4)	35.3 (22.2)	32.1 (22.6)	0.019
Adults, n (%)	781 (72)	412 (76)	369 (67)	
Pediatric, n (%)	309 (28)	129 (24)	180 (33)	0.001
Female, n (%)	626 (57)	303 (56)	323 (59)	0.35
Race, n (%) (N = 1084; 538; 546) ^a				
White	926 (85)	470 (87)	456 (84)	0.073
Other	158 (15)	68 (13)	90 (16)	
Suspected Allergen, n (%)				
Food	404 (37)	213 (39)	191 (35)	0.002
Medication	182 (17)	90 (17)	92 (17)	
Venom	166 (15)	98 (18)	68 (12)	
Contrast	50 (5)	24 (4)	26 (5)	
Other	51 (5)	16 (3)	35 (6)	
Unknown	237 (22)	100 (18)	137 (25)	

(continued on next page)

Table 1 (continued)

Feature	All visits (N = 1090)	Higher acuity ESI (Level 1 or 2) (N = 541)	Lower acuity ESI (Level 3 or 4) (N = 549)	P value
Suspected allergen, n (%)				
Known	853 (78)	441 (82)	412 (75)	0.01
Unknown	237 (22)	100 (18)	137 (25)	
History of anaphylaxis, n (%)	383 (35)	207 (38)	176 (32)	0.032
History of asthma, n (%)	284 (26)	143 (26)	141 (26)	0.78
Mean systolic blood pressure, mmHg (SD) (N = 947:483:464) ^a	132 (23)	134 (24)	129 (22)	0.002
Mean diastolic blood pressure, mmHg (SD) (N = 947:483:464) ^a	78 (17)	79 (18)	77 (16)	0.021
Mean arterial pressure, mmHg (SD) (N = 947:483:464) ^a	96 (17)	97 (18)	94 (16)	0.004
Mean heart rate, beats per minute (SD) (N = 1088:540:548) ^a	98 (23)	101 (24)	95 (22)	<0.001
Median respiratory rate, breaths per minute (IQR) (N = 1082:535:547) ^a	19 (16–22)	20 (17–24)	18 (16–20)	<0.001
Median SpO ₂ in % (IQR) (N = 994:487:507) ^a	98 (96–99)	98 (96–100)	98 (96–99)	0.43
Presenting Signs and symptoms				
Mucocutaneous	1066 (98)	528 (98)	538 (98)	0.65
Flushing	434 (40)	231 (43)	203 (37)	0.054
Pruritus	489 (45)	221 (41)	268 (49)	0.008
Diffuse urticaria	401 (37)	185 (34)	216 (39)	0.078
Throat tightness	545 (50)	294 (54)	251 (46)	0.004
Oral pruritus or tingling	193 (18)	96 (18)	97 (18)	0.97
Chemosis/conjunctivitis	100 (9)	53 (10)	47 (9)	0.48
Angioedema	646 (59)	341 (63)	305 (56)	0.012
Face or periorbital	394 (36)	207 (38)	187 (34)	0.15
Posterior pharynx or uvula	152 (14)	96 (18)	56 (10)	<0.001
Extremities	57 (5)	23 (4)	34 (6)	0.15
Lips	306 (28)	154 (28)	152 (28)	0.77
Tongue	209 (19)	120 (22)	89 (16)	0.012
Other	28 (3)	12 (2)	16 (3)	0.47
Gastrointestinal	517 (47)	250 (46)	267 (49)	0.42
Emesis	198 (18)	100 (18)	98 (18)	0.79
Nausea	347 (32)	164 (30)	183 (33)	0.28
Abdominal cramping/pain	196 (18)	86 (16)	110 (20)	0.075
Diarrhea	66 (6)	33 (6)	33 (6)	0.95
Respiratory	908 (83)	463 (86)	445 (81)	0.045
Laryngeal edema	10 (1)	7 (1)	3 (1)	0.22
Cough	237 (22)	113 (21)	124 (23)	0.5
Voice change	254 (23)	138 (26)	116 (21)	0.087
Dyspnea/difficulty breathing	683 (63)	360 (67)	323 (59)	0.009
Wheezing/bronchospasm	332 (30)	173 (32)	159 (29)	0.28
Cyanosis	15 (1)	8 (1)	7 (1)	0.77
Stridor	50 (5)	29 (5)	21 (4)	0.23
Hypoxemia	60 (6)	44 (8)	16 (3)	<0.001
Cardiovascular	363 (33)	179 (33)	184 (34)	0.88
Hypotension	79 (7)	47 (9)	32 (6)	0.069
Presyncope	318 (29)	150 (28)	168 (31)	0.3
Syncope	71 (7)	40 (7)	31 (6)	0.24
Incontinence	14 (1)	7 (1)	7 (1)	0.98
Chief concern, n (%)				
Allergic/medication reaction	799 (73)	415 (77)	384 (70)	<0.001
Shortness of breath/dyspnea/wheezing	65 (6)	35 (6)	30 (5)	
Bee/wasp/insect sting	51 (5)	27 (5)	24 (4)	
Hives/rash/pruritus	50 (5)	13 (2)	37 (7)	
Anaphylaxis	23 (2)	20 (4)	3 (1)	
Other	102 (9)	31 (6)	71 (13)	
Pre-hospital epinephrine administered, n (%)				
Home	195 (18)	109 (20)	86 (16)	0.054
EMS	149 (14)	100 (18)	49 (9)	<0.001
Home or EMS	324 (30)	192 (35)	132 (24)	<0.001
Median minutes from arrival to first epinephrine in ED (IQR) (N = 502:284:218) ^a	18 (10–37)	13 (7–23)	28 (15–48)	<0.001
Median waiting room length of stay in minutes (IQR)	4 (2–9)	3 (2–7)	5 (2–13)	<0.001
Median ED length of stay in hours (IQR)	2.2 (1.5–3.2)	2.2 (1.5–3.4)	2.2 (1.5–3.2)	0.73
Data source, n (%)				
Retrospective	773 (71)	381 (70)	392 (71)	0.72
Prospective	317 (29)	160 (30)	157 (29)	
Disposition, n (%)				
Home	491 (45)	195 (36)	296 (54)	<0.001
ED observation unit	465 (43)	259 (48)	206 (38)	
Hospital ward	78 (7)	45 (8)	33 (6)	
Intensive Care Unit	56 (5)	42 (8)	14 (2)	
Post-arrival epinephrine administered, n (%)				
ED	503 (46)	285 (53)	218 (40)	<0.001
ED observation unit	5 (<1)	3 (1)	2 (<1)	0.68
Biphasic reaction, n (%)	82 (8)	39 (7)	43 (8)	0.70

ESI, Emergency Severity Index; ED, Emergency department; SD, standard deviation; IQR, interquartile range; OR, odds ratio; EMS, Emergency medical services.

^a Adjusted N reflect missing values.

race, history of asthma, or prospective versus retrospective enrollment between the lower and higher acuity ESI groups.

Patients with a higher acuity ESI level were more likely to have a history of anaphylaxis (38% versus 32%), present with angioedema (63% versus 56%), dyspnea (67% versus 59%), hypoxia (8% versus 3%), and throat tightness (54% versus 46%). Visits with lower acuity ESI levels had a greater proportion of pediatric patients than higher acuity visits (33% versus 24%) and were less likely to present with an identified inciting allergen compared to higher ESI visits (75% versus 82%). Patients with visits that were assigned a lower acuity ESI level of 3 or 4 were less likely to have received epinephrine by EMS (49/549 [9%] versus 100/541 [18%], OR 0.43 [95% CI, 0.30–0.62]) and less likely to receive epinephrine in the ED compared to the higher ESI group (218/549 [40%] versus 285/541 [53%], OR 0.59 [95% CI, 0.47–0.75]). Furthermore, patients with visits in the lower acuity group received epinephrine later during their ED evaluation, with a median (IQR) time of administration of the first dose of epinephrine at 28 (15–48) minutes after ED arrival compared to 13 (7–23) minutes for the group with higher acuity ESI levels.

Because it is possible for patients presenting to the ED with mild allergic symptoms to have symptom progression after ED triage, we separately reevaluated all patients who were triaged to a level 3 or 4 and received epinephrine in the ED. Of the 218 patients who were assigned an ESI level of 3 or 4 and received epinephrine in the ED, 12 patients experienced progression of their reaction symptoms after ED triage and 1 patient received epinephrine for a biphasic reaction. When these 13 patients were excluded from the analysis, there were a total of 205 out of 549 patients (37%) with an ESI level of 3 or 4 who received epinephrine in the ED. Among these 205 patients the median (IQR) time to epinephrine administration was 25 (14–46) minutes which represents a statistically significant delay in epinephrine administration compared to patients with an ESI level of 1 or 2 ($p < .001$).

Patients with an ESI level of 1 or 2 were more likely to be admitted compared to those with an ESI level of 3 or 4 (16% versus 8.6%). There were no anaphylaxis-related deaths among the 1090 patient visits.

3.5. Multivariable analysis of factors associated with triage ESI level

Table 2 shows a multivariable analysis predicting features associated with triage to a lower acuity ESI level versus a higher acuity ESI level. Based on this multivariable model, visits were more likely to be triaged to an ESI level of 3 or 4 when patients presented with a chief concern of hives, rash, or pruritus (OR 2.33 [95% CI, 1.20–4.53]) or a chief concern

other than concerns that are typical for anaphylaxis or allergic reactions (OR 2.97 [95% CI, 1.82–4.84]). Visits were less likely to be assigned an ESI level of 3 or 4 when patients were adults (OR, 0.43 [95% CI, 0.31–0.60]) or presented with a chief concern of anaphylaxis (OR 0.19 [95% CI, 0.06–0.68]), with posterior pharyngeal or uvular angioedema (OR, 0.56 [0.38–0.82]), or hypoxemia (OR, 0.34 [0.18–0.64]). Visits among patients presenting with lower triage heart rates and respiratory rates were also more likely to be assigned a lower acuity triage levels.

4. Discussion

We studied ED triage in a cohort of 1090 anaphylaxis patients and found that approximately half were assigned an ESI triage level indicating high acuity (level 1 or 2) while the remaining half of patients were assigned a lower acuity triage level (level 3 or 4). We grouped patients into ESI levels 1 and 2 versus ESI levels 3 and 4 because patients requiring expedited care include patients who require immediate life-saving interventions (level 1) and high-risk patients at who are at risk of deterioration, may require time-sensitive treatment, or have concerning vital signs (level 2). The lower acuity ESI levels 3 through 5 are based on anticipated resource need. Although most anaphylactic reactions are not life-threatening, our inability to predict who will have rapid progression to a life-threatening reaction necessitates rapid ED evaluation. Patients with lower acuity ESI levels were less likely to receive epinephrine in the ED and received it later than patients triaged to higher acuity ESI levels. Children, patients with skin-related chief concerns (hives, rash, or pruritus), or non-allergy related chief concerns were more likely to be assigned an ESI level of 3 or 4. In contrast, patients who received epinephrine from EMS presented with posterior pharyngeal angioedema, hypoxemia or elevated respiratory or heart rates were more likely to be assigned higher acuity triage levels. To our knowledge, ours is the largest study assessing ED anaphylaxis triage and the first to assess anaphylaxis triage based on the ESI, including both adult and pediatric anaphylaxis cases.

Importantly, 37% of patients, without progression of their reaction after triage, who were triaged to lower acuity ESI levels (levels 3 or 4) received epinephrine in the ED, representing 19% of the entire cohort. Furthermore, these patients received epinephrine 12 min later during their ED evaluation compared to those assigned higher acuity ESI levels (levels 1 and 2). Given that epinephrine administration is time sensitive and anaphylaxis patients are at risk of deterioration, these results suggest that at least 19% of ED anaphylaxis patients were potentially under-triaged. However, it could also be argued for the same reasons, i.e. risk of progression and time-sensitive nature of epinephrine administration, that all anaphylaxis patients who were not in need of an immediate life-saving intervention should be considered high-risk according to the ESI, and therefore should have been assigned an ESI level of 2. Indeed, it is likely that anaphylaxis was not recognized at triage in many patients who were triaged to an ESI level of 3 or 4 and that these patients were thought to be experiencing a simple allergic reaction or other medical condition. Based on this interpretation, over half of our cohort was under-triaged. However, it is also possible, given that anaphylaxis is often self-limited and that approximately one-quarter of patients assigned an ESI level of 3 or 4 had received prehospital epinephrine, that the anaphylactic reaction may have been resolved or nearly resolved in some patients at the time of triage. Furthermore, 63% of patients assigned a triage level of 3 or 4 did not require epinephrine in the ED suggesting that the lower acuity ESI level may have been appropriate in some patients. Taken together, our findings suggest that between 20 and 50% of anaphylaxis patients may have been potentially under-triaged.

Delayed epinephrine administration among those with lower acuity levels with anaphylaxis increases their risk for poor outcomes. Delayed epinephrine administration has been demonstrated to be a risk factor for fatal anaphylaxis, especially related to food. In a review of a registry of fatal food anaphylaxis cases, Bock et al. [2] found that only 4 out of 31

Table 2

Multivariable associations predicting lower acuity ESI level (ESI 3 or 4) versus higher acuity ESI level (ESI level 1 or 2)

Feature	Odds Ratio (95% CI)	P-value
Age in years		
<18	1.0 (reference)	<0.001
≥18	0.43 (0.31–0.60)	
Signs and symptoms		
Posterior pharyngeal or uvular angioedema	0.56 (0.38–0.82)	0.003
Hypoxemia	0.34 (0.18–0.64)	<0.001
Chief concern		
Allergic/medication reaction	1.0 (reference)	
Anaphylaxis	0.19 (0.06–0.68)	0.010
Dyspnea/wheezing	1.15 (0.67–1.97)	0.60
Bee/wasp/insect sting	1.04 (0.57–1.89)	0.89
Hives/rash/pruritus	2.33 (1.20–4.53)	0.013
Other	2.97 (1.82–4.84)	<0.001
Heart rate in beats per minute ^a	0.83 (0.73–0.95)	0.005
Respiratory rate in breaths per minute ^b	0.70 (0.60–0.82)	<0.001
EMS epinephrine administered	0.56 (0.38–0.82)	0.003

ESI, Emergency Severity Index; EMS, Emergency medical services.

^a Odds ratio and CI represent a 20-unit increase in heart rate.

^b Odds ratio and CI represent a 5-unit increase in respiratory rate.

subjects received epinephrine in a timely manner. Furthermore, in a retrospective case-series from the Ontario coroner's database from 1986 to 2011, Xu et al. [12] found that only 23% of anaphylaxis cases received epinephrine prior to cardiac arrest. In addition to being a risk factor for fatal anaphylaxis, delayed epinephrine administration may also increase the risk of developing a biphasic reaction. This has been demonstrated in several previous studies [13–15]. Liu et al. [13] demonstrated in a prospective cohort series of 430 ED anaphylaxis visits that a delay of more than 30 min from symptom onset to epinephrine administration was associated with a biphasic course (OR, 3.39; 95% CI, 1.13–10.18). Alqurashi et al. [14] reported that biphasic reactions in children were associated with a delay in epinephrine treatment by more than 90 min (OR 2.58, 95% CI 1.47–4.53). Lee and Greenes [15] reported that the median time to initial dose of epinephrine in patients experiencing a biphasic reaction was significantly longer (190 versus 48 min) in comparison to those who did not experience a biphasic reaction.

Our finding that 49% of visits overall and 42% of pediatric visits were assigned an ESI level of 1 or 2 demonstrate more accurate anaphylaxis triage than those reported in a study of pediatric ED anaphylaxis triage [3]. Using the Canadian Pediatric Emergency Triage and Acuity Scale (PaedCTAS) [16], a 5-level priority system specifically for pediatric patients, Arrobarren et al. found that only one third of pediatric anaphylaxis cases were triaged to the two highest acuity levels. In addition, they also found that rates of epinephrine administration were higher in those triaged to higher acuity levels. Anaphylaxis cases that were more likely to be under-triaged included patients with stable appearance according to the Pediatric Assessment Triangle (PAT) [17], in addition to normal vital signs.

In our cohort, children with anaphylaxis were more likely to be triaged to a lower acuity ESI level. One potential explanation for this finding is that the absence of specialized pediatric triage staff familiar with childhood presentations contributed to the failure to identify subtle pediatric anaphylaxis cases. However, as noted above, Arrobarren et al. demonstrated a higher rate of inaccurate triage in a dedicated pediatric ED, where only 33% of cases were triaged to the higher acuity triage levels, suggesting that dedicated pediatric staff may not improve pediatric anaphylaxis triage. Another potential explanation would be that the ESI algorithm is less effective at identifying pediatric anaphylaxis but, also as noted above, the use of a pediatric triage system (PaedCTAS) did not result in a greater proportion of triage of pediatric patients to higher acuity triage levels. A more likely explanation for why children with anaphylaxis have lower triage levels is their lack of ability to verbally communicate subjective symptoms such as throat tightness, dyspnea, nausea, and lightheadedness. Also for many children this might be their first reaction, and a caregiver's inability to recognize exposures or likely triggers for an allergic reaction may be a contributing factor.

We found that patients presenting with rash, urticaria, or pruritus were more likely to be triaged to an ESI level 3 or 4. Jung et al. [18] demonstrated that 3.5% (37/1051) of pediatric patients presenting with urticaria were missed cases of anaphylaxis. Prominent skin related concerns may result in the cognitive error of anchoring to a suspicion of a simple allergic reaction rather than assessment for possible anaphylaxis.

Our multivariable analysis showed that patients with posterior pharyngeal angioedema or hypoxemia were less likely to be assigned a lower acuity ESI level. This would be expected as these findings indicate risk of airway compromise and for that reason are more likely to be triaged to higher acuity levels. However, of those with a lower acuity ESI level, 16% had tongue angioedema and 10% had posterior pharyngeal angioedema suggesting that these signs may be under-identified at triage. Moreover, the presence of hypoxemia ($\text{SaO}_2 < 92\%$) and distressed appearance are both explicitly included in the ESI, which provides direct actionable guidance on how to triage these patients [7].

In general, we found that patients with more severe presentations were accurately triaged to ESI levels 1 or 2. Those with angioedema,

dyspnea, hypoxia and throat tightness, increased respiratory and heart rates were more likely to be triaged as higher acuity. However, our results demonstrate an opportunity for improvement in the triage of patients with anaphylaxis, particularly in children and those who present with skin-related chief concerns.

Our findings suggest that ED anaphylaxis triage needs improvement to reduce the risk of delayed epinephrine and poor outcomes. In a subsequent study by Arrobarren et al., a training lecture was provided to pediatric emergency unit nurses and triage priority level was assessed in patients with anaphylaxis before and after the intervention. Following the intervention, the number of correctly identified anaphylaxis patients increased from 36.2% to 72.2%, and wait times decreased from 8 min to 1 min. These results show that simple measures can significantly improve the identification of anaphylaxis in triage [19].

4.1. Limitations

Our study has several limitations. We identified anaphylaxis cases based on the NIAID/FAAN anaphylaxis diagnostic criteria which have been shown to have a sensitivity of 95% but specificity of 71% [20]. Thus, it is possible that not all cases included in our study represented anaphylaxis. However, the NIAID/FAAN criteria are currently the most widely accepted diagnostic criteria for the study of anaphylaxis [21]. Furthermore, there are no objective independent tests available for the diagnosis of anaphylaxis. Approximately 70% of our patients were enrolled retrospectively and therefore the data quality is dependent on the accuracy of the medical record. To mitigate this limitation, we followed standardized guidelines for observational studies and used a data abstraction form to optimize precision and accuracy of collected variables and to minimize random and systematic errors. Reassuringly, we didn't find a difference in triage levels between prospectively and retrospectively enrolled patients. Additionally, our findings cannot be generalized to EDs that do not use the ESI for triage. However, the ESI has been validated for use in both adult and pediatric patients [7,22] and is the most widely used triage algorithm in the United States [4]. We conducted our study in a single quaternary care ED with a predominantly white patient population, which could limit generalizability to other settings. Additionally, 30% of patients received pre-hospital epinephrine which may raise concern that patients whose symptoms of anaphylaxis had improved with epinephrine would be triaged to lower levels after treatment. However, we found that the opposite was true in that patients were more likely to be triaged a level 1 or 2 if they received epinephrine pre-hospital. Not all anaphylaxis patients in our cohort received epinephrine for management of their reaction, suggesting that some patients may not have experienced anaphylaxis. However, many cases of anaphylaxis are self-limited and no longer require epinephrine at the time of ED presentation. This was demonstrated by Baalman et al. [22] in a prospective observational study in which two allergy-immunologists independently reviewed cases of anaphylaxis and subsequent ED management. They found that although only 77% of ED anaphylaxis patients had received epinephrine for management of their reaction, the allergists deemed that management was appropriate in 98% of patients. In addition, blood pressure measurements were missing in 13% of patient visits and oxygen saturations were missing in 9% of patient visits which could have impacted our analysis. Triage vital sign documentation has been shown to be problematic in other EDs with studies reporting similar and lower rates of documentation [23,24]. Finally, we did not identify any differences in patient-oriented outcomes related to the ED triage level. However, given that we had short waiting room lengths of stay regardless of the triage level, and that poor outcomes are relatively rare in anaphylaxis, this is not unexpected. Nonetheless, the increased risk of poor outcomes secondary to delayed identification and treatment of anaphylaxis is still important.

5. Conclusion

Our findings demonstrate that approximately one-fifth to one-half of patients meeting anaphylaxis diagnostic criteria may be under-triaged which may have contributed to delayed epinephrine administration. Those who were triaged to lower ESI acuity levels were more likely to be children or to have a skin-related chief concerns. None of the patients had fatal outcomes. Further studies are needed to identify practice improvement initiatives for ED anaphylaxis triage.

Funding source

None.

Presented at American College of Emergency Physicians Scientific Assembly, October 28, 2019.

CRediT author statement

Daniel Chiang: Conceptualization, Methodology, Investigation, Writing – Original Draft, Writing – Review & Editing, Visualization
Justine M. Ade: Writing – Original Draft, Writing – Review & Editing, Visualization
Xiao-wei Liu: Methodology, Investigation, Writing – Review & Editing
Fernanda Bellolio: Methodology, Resources, Writing – Review & Editing
Christine M. Lohse: Methodology, Validation, Formal analysis, Data Curation, Writing – Review & Editing
Benjamin J. Sandefur: Methodology, Writing – Review & Editing
Ronna L. Campbell: Conceptualization, Methodology, Investigation, Writing – Original Draft, Writing – Review & Editing, Visualization, Supervision, Project administration.

Declaration of Competing Interest

R.L. Campbell has been a consultant for Bryn Pharma. The rest of the authors declare that they have no relevant conflicts of interest.

References

- [1] Turner PJ, Jerschow E, Umasunthar T, Lin R, Campbell DE, Boyle RJ. Fatal anaphylaxis: mortality rate and risk factors. *J Allergy Clin Immunol Pract.* 2017;5(5):1169–78.
- [2] Bock SA, Muñoz-Furlong A, Sampson HA. Fatalities due to anaphylactic reactions to foods. *J Allergy Clin Immunol.* 2001;107(1):191–3.
- [3] Arroabarren E, Alvarez-García J, Anda M, de Prada M, Ponce MC, Palacios M. Quality of the Triage of Children With Anaphylaxis at the Emergency Department. *Pediatr Emerg Care.* 2018 May 15. <https://doi.org/10.1097/PEC.0000000000001442> Epub ahead of print. PMID: 29768291.
- [4] McHugh M, Tanabe P, McClelland M, Khare RK. More patients are triaged using the emergency severity index than any other triage acuity system in the United States. *Acad Emerg Med.* 2012;19(1):106–9.
- [5] Wuerz RC, Milne LW, Eitel DR, Travers D, Gilboy N. Reliability and validity of a new five-level triage instrument. *Acad Emerg Med.* 2000;7(3):236–42.
- [6] Eitel DR, Travers DA, Rosenau AM, Gilboy N, Wuerz RC. The emergency severity index triage algorithm version 2 is reliable and valid. *Acad Emerg Med.* 2003;10(10):1070–80.
- [7] Tanabe P, Gimbel R, Yarnold PR, Kyriacou DN, Adams JG. Reliability and validity of scores on the emergency severity index version 3. *Acad Emerg Med.* 2004;11(1):59–65.
- [8] Agency for Healthcare Research and Quality. Emergency Severity Index (ESI): A triage tool for emergency departments; 2020, May Available from <https://www.ahrq.gov/professionals/systems/hospital/esi/index.html>.
- [9] von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP, et al. Strengthening the reporting of observational studies in epidemiology (STROBE) statement: guidelines for reporting observational studies. *BMJ.* 2007;335(7624):806–8.
- [10] Campbell RL, Bashore CJ, Lee S, Bellamkonda VR, Li JT, Hagan JB, et al. Predictors of repeat epinephrine Administration for Emergency Department Patients with anaphylaxis. *J Allergy Clin Immunol Pract.* 2015;3(4):576–84.
- [11] Sampson HA, Muñoz-Furlong A, Campbell RL, Adkinson Jr NF, Bock SA, Branum A, et al. Second symposium on the definition and management of anaphylaxis: summary report—second National Institute of allergy and infectious disease/Food Allergy and Anaphylaxis Network symposium. *J Allergy Clin Immunol.* 2006;117(2):391–7.
- [12] Xu YS, Kastner M, Harada L, Xu A, Salter J, Wasserman S. Anaphylaxis-related deaths in Ontario: a retrospective review of cases from 1986 to 2011. *Allergy Asthma Clin Immunol.* 2014;10(1):38.
- [13] Liu X, Lee S, Lohse CM, Hardy CT, Campbell RL. Biphasic reactions in emergency department anaphylaxis patients: a prospective cohort study. *J Allergy Clin Immunol Pract.* 2020;8(4):1230–8.
- [14] Alqurashi W, Stiell I, Chan K, Neto G, Alsadoon A, Wells G. Epidemiology and clinical predictors of biphasic reactions in children with anaphylaxis. *Ann Allergy Asthma Immunol.* 2015;115(3):217–23 [e2].
- [15] Lee JM, Greenes DS. Biphasic anaphylactic reactions in pediatrics. *Pediatrics.* 2000;106(4):762–6.
- [16] Warren DW, Jarvis A, LeBlanc L, Gravel J. Revisions to the Canadian triage and acuity scale paediatric guidelines (PaedCTAS). *Cjem.* 2008;10(3):224–43.
- [17] Dieckmann RA, Brownstein D, Gausche-Hill M. The pediatric assessment triangle: a novel approach for the rapid evaluation of children. *Pediatr Emerg Care.* 2010;26(4):312–5.
- [18] Jung WS, Kim SH, Lee H. Missed Diagnosis of Anaphylaxis in Patients With Pediatric Urticaria in Emergency Department. *Pediatr Emerg Care.* 2018. <https://doi.org/10.1097/PEC.0000000000001617> Epub ahead of print. PMID: 30281553.
- [19] Arroabarren E, Alvarez-García J, Anda M, de Prada M, Ponce C, Alvarez-Puebla MJ. Impact of specific training in anaphylaxis for triage nursing staff in the pediatric emergency Department of a Tertiary Hospital. *J Investig Allergol Clin Immunol.* 2018;28(6):401–6.
- [20] Loprinzi Brauer CE, Motosue MS, Li JT, Hagan JB, Bellolio MF, Lee S, et al. Prospective validation of the NIAID/FAAN criteria for emergency department diagnosis of anaphylaxis. *J Allergy Clin Immunol Pract.* 2016;4(6):1220–6.
- [21] Simons FER, Ebisawa M, Sanchez-Borges M, et al. 2015 update of the evidence base: world allergy organization anaphylaxis guidelines. *World Allergy Organ J.* 2015;8:1–16.
- [22] Green NA, Durani Y, Brecher D, DePiero A, Loiselle J, Attia M. Emergency severity index version 4: a valid and reliable tool in pediatric emergency department triage. *Pediatr Emerg care.* 2012;28(8):753–[22]Baalmann DV, Hagan JB, Li JT, Hess EP, Campbell RL. Appropriateness of epinephrine use in ED patients with anaphylaxis. *Am J Emerg Med.* 2016;32(2):175–9.
- [23] Silverman MA, Walker AR, Nicolaou DD, Bono MJ. The frequency of blood pressure measurements in children in four EDs. *Am J Emerg Med.* 2000;18(7):784–8.
- [24] Armstrong B, Walthall H, Clancy M, Mullee M, Simpson H. Recording of vital signs in a district general hospital emergency department. *Emerg Med J.* 2008;25(12):799–802.