

ANAPHYLAXIS KNOWLEDGE AMONG PARAMEDICS: RESULTS OF A NATIONAL SURVEY

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ABSTRACT

Background. Very little is known about prehospital providers' knowledge regarding anaphylaxis care. **Objectives.** The purpose of this study was to evaluate how well nationally registered paramedics in the United States recognize classic and atypical presentations of anaphylaxis. We also assessed knowledge regarding treatment with epinephrine, including dosing, route of administration, and perceived contraindications to epinephrine use. **Methods.** This was a blinded, cross-sectional online survey of a random sample of paramedics registered by the National Registry of Emergency Medical Technicians that was distributed via e-mail. The survey contained two main sections: demographic data/self-assessment of confidence with anaphylaxis care and a cognitive assessment. **Results.** A total of 3,537 paramedics completed the survey, for a 36.6% response rate. Among the respondents, 98.9% correctly recognized a case of classic anaphylaxis, whereas only 2.9% correctly identified the atypical presentation. Regarding treatment, 46.2% identified epinephrine as the initial drug of choice; 38.9% chose the intramuscular (IM) route of

administration, and 60.5% identified the deltoid as the preferred location (11.6% thigh). Of the respondents, 98.0% were confident they could recognize anaphylaxis; 97.1% were confident they could manage anaphylaxis; 39.5% carry epinephrine autoinjectors (EAI) on response vehicles; 95.4% were confident they could use an EAI; and 36.2% stated that there were contraindications to epinephrine administration in anaphylactic shock. **Conclusions.** Whereas a large percentage of the paramedics recognized classic anaphylaxis, a very small percentage recognized atypical anaphylaxis. Less than half chose epinephrine as the initial drug of choice, and most respondents were unable to identify the correct route/location of administration. This survey identifies a number of areas for improved education. **Key words:** anaphylaxis; emergency medical technician; epinephrine

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INTRODUCTION

Numerous studies have reported that anaphylaxis is both underrecognized and undertreated by patients, caregivers, and physicians.^{1–5} Evidence also suggests that patients and providers do not know how or when to correctly administer epinephrine autoinjectors (EAI).^{2–12} Whereas it is important to continue improving patient, caregiver, and physician education regarding anaphylaxis and its treatment, it is important to note that anaphylaxis occurs suddenly, without warning, and most often in the out-of-hospital environment. It is vitally important to ensure that prehospital providers understand how to appropriately recognize anaphylaxis in order to administer potentially lifesaving medications prior to reaching the hospital.

We recently reported a case of unrecognized prehospital anaphylactic shock in a patient who presented with sudden onset of recurrent syncope and a preponderance of gastrointestinal (GI) complaints, including vomiting, diarrhea, and abdominal pain accompanied by severe hypotension.¹³ The patient lacked any known typical exposures and did not present with urticaria. This led our research team to pursue the questions regarding how well emergency medical services (EMS) providers recognize both classic and atypical presentations of anaphylaxis. To date, no published report has sought to comprehensively evaluate a national sample of EMS providers regarding anaphylaxis recognition and care.

The primary purpose of our study was to determine how well nationally registered paramedics in the

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United States recognize classic and atypical presentations of anaphylaxis. In addition, we also sought to assess their knowledge regarding treatment of anaphylaxis with epinephrine including dosing, route of administration, and perceived contraindications to epinephrine use. We included demographic descriptors, as well as self-reported confidence of providers in their ability to recognize and treat anaphylaxis, and knowledge regarding EAI use.

METHODS

Study Design and Population

This was a cross-sectional survey sent electronically to a random sample of nationally certified paramedics. A sample of 10,350 paramedics were randomly generated from the entire pool of 41,793 registered paramedics who had e-mail addresses by the National Registry of Emergency Medical Technicians (NREMT; Columbus, OH), the national certifying agency for all EMS providers in the United States. Electronic informed consent was obtained and this study was approved by the University of Missouri–Kansas City Adult Health Sciences Institutional Review Board.

Survey Content and Administration

A 75-question survey was developed by the research team. The research team consisted of academic emergency medicine physicians, two of whom were former prehospital providers. The team also included two experts in survey methodology who have extensive experience in the administration and analysis of national surveys. The survey was reviewed for face validity by two community emergency medicine physicians who serve as EMS medical directors/educators and were not part of the research team. The survey was also reviewed for content validity by an independent practicing academic allergist/immunologist who also had experience in survey research. In order to adequately assess a broad range of anaphylaxis topics and still blind the participant to intent, it was necessary to create a lengthy survey with many distractors covering other prehospital issues. The survey was pilot-tested on 175 EMS providers in multiple different community EMS agencies to assess readability, to clarify any confusing questions, to determine average time to completion, and to ensure blinding to the true intent of the survey. Appropriate revisions were made based on pilot-testing, and only one of 175 pilot participants stated that the survey's intent may be to test providers on knowledge of anaphylaxis care.

The survey was Web-based and administered by SurveyMonkey (Portland, OR) via e-mail. An initial e-mail message was sent with an introductory letter inviting subjects to voluntarily participate in a generic

survey study regarding various prehospital practices. Of the original 10,350 e-mail addresses obtained from the NREMT, 9,655 were successfully e-mailed. The subjects were informed of the possible time commitment of 20 minutes to complete the survey and were given assurance of confidentiality. If participants did not opt out of the study, they were contacted up to three additional times via e-mail to ensure compliance.

The survey contained many distractors regarding various prehospital scenarios and interventions and included topics such as childbirth, pediatric respiratory distress, pediatric and adult trauma, asthma, acute myocardial infarctions, cardiovascular medications, intraosseous (IO) devices, and defibrillation dosages, among several others, in order to blind the participant to intent. Questions in the survey were ordered identically to the pilot-testing.

The survey was broken down into two main sections. The first section collected demographic data as well as self-reported confidence in both recognition and management of anaphylaxis. The second section was a knowledge test consisting of a combination of multiple-choice and open-ended responses regarding anaphylaxis care and other EMS topics noted above. Open-ended responses were utilized to avoid leading the respondent unintentionally to a predefined response and to reduce the likelihood of respondents' recognizing the correct answer.

Data Analysis

Descriptive statistics were analyzed using SPSS (version 18; SPSS, Inc., Chicago, IL). Not all respondents answered all questions; therefore, for the purpose of these analyses, results were calculated based on responses to a particular question. However, all surveys that were analyzed had at least 80% of the questions answered. In order to determine how our sample differed demographically from the national sample, we performed bivariate comparisons using an independent-samples t-test for the comparison of age, and chi-square comparisons for gender, education, years of experience, size of the community, and type of EMS service. Multiple-choice question data were managed by SurveyMonkey and were directly exported to an Excel spreadsheet (Microsoft Corp., Redmond, WA). Free-text responses in the knowledge portion of the survey were dealt with in the following two ways. For simple responses regarding dosing, route of administration of epinephrine, and diagnoses, a range of acceptable correct responses were determined prior to distributing the survey. Free-text responses asking for perceived contraindications to epinephrine were grouped into categories by the principal investigator using a pilot sample of 100 returned surveys. Answers were then analyzed individually by two emergency medicine physicians on the research team, and if there was disagreement, a third emergency medicine

TABLE 1. Demographic Data

Variable	Study Sample	95% CI	National EMS Workforce*	95% CI
Age—mean $\pm$ SD, years	n = 3,537 36.0 $\pm$ 9.5	35.7–36.3	n = 1,483 35.7 $\pm$ 11.2	35.1–36.3
Gender—male, (%) n	n = 3,537 (79.0) 2,795	77.7–80.3%	n = 1,490 (72.0) 1,072	69.6–74.2%
Educational level, (%) n	n = 3,537		n = 1,622	
High school	(4.0) 141	3.4–4.7%	(7.9) 129	6.7–9.4%
Some college	(36.0) 1,273	34.4–37.6%	(39.2) 637	36.9–41.7%
Associate's degree	(29.7) 1,051	28.2–31.2%	(24.9) 404	22.9–27.1%
Bachelor's degree	(23.5) 830	22.1–24.9%	(21.8) 354	19.9–23.9%
Master's/PhD/MD/DO degree	(6.8) 242	6.1–7.7%	(6.0) 98	5.0–7.3%
Years of experience, (%) n	n = 3,537		n = 1,496	
Less than 1 year	(0.5) 16	0.3–0.7%	(18.2) 272	16.3–20.2%
1 to 2 years	(5.8) 205	5.1–6.6%	(13.4) 200	11.7–15.2%
3 to 4 years	(11.2) 397	10.2–12.3%	(15.9) 238	14.1–17.9%
5 to 7 years	(19.3) 683	18.0–20.6%	(16.3) 244	14.5–18.3%
8 to 10 years	(17.2) 610	16.0–18.5%	(13.0) 194	11.4–14.8%
11 to 15 years	(16.6) 586	15.4–17.8%	(9.7) 145	8.3–11.3%
16 to 20 years	(14.4) 511	13.3–15.6%	(6.4) 97	5.3–7.9%
21 years or more	(15.0) 529	13.8–16.2%	(7.0) 106	5.9–8.5%
Size of community, (%) n	n = 3,537		n = 1,383	
Rural area (less than 2,500)	(3.9) 137	3.3–4.6%	(11.5) 159	9.9–13.3%
Small town (2,500–24,999)	(20.9) 738	19.6–22.2%	(28.1) 389	25.8–30.6%
Medium town (25,000–74,999)	(22.4) 794	21.1–23.9%	(16.9) 234	15.0–19.0%
Mid-sized city (150,000–499,999)	(15.8) 559	14.6–17.0%	(11.2) 155	9.7–13.0%
Suburb/fringe of mid-sized city	(2.8) 99	2.3–3.4%	(3.2) 44	2.4–4.2%
Large city	(14.1) 498	13.0–15.3%	(15.0) 208	13.3–17.0%
Large town (75,000–149,999)	(16.1) 570	14.9–17.4%	(9.0) 124	7.6–10.6%
Suburb/fringe of large city	(4.0) 142	3.4–4.7%	(5.1) 70	4.0–6.4%
Type of EMS service, (%) n	n = 3,537		n = 1,243	
Fire	(31.0) 1,095	29.5–32.5%	(40.0) 497	37.3–42.7%
Private	(27.9) 987	26.5–29.4%	(28.1) 349	25.7–30.6%
County	(17.2) 610	16.0–18.5%	(14.4) 179	12.6–16.5%
Hospital	(12.9) 458	11.9–14.1%	(9.7) 121	8.2–11.5%
Military	(1.7) 61	1.4–2.2%	(1.8) 22	1.2–2.7%
Other	(9.2) 326	8.3–10.2%	(6.1) 75	4.8–7.5%

*National EMS workforce data obtained from the Longitudinal Emergency Medical Technician Attributes and Demographic Study (LEADS) and provided by the National Registry of Emergency Medical Technicians (NREMT) for the latest year of data collected (2008).

CI = confidence interval; EMS = emergency medical services; SD = standard deviation.

physician made the final determination as to the appropriate category in which to place the response.

RESULTS

A total of 9,655 randomly selected paramedics were sent e-mail invitations to participate in the online survey from December 1, 2010, to March 1, 2010; up to three reminders were sent. A total of 3,537 paramedics completed the survey, for a response rate of 36.6%. The total number of nationally registered paramedics according to the NREMT annual report in 2010 was 72,544.¹⁴ Our sample size represents approximately 5% of all nationally registered paramedics in the United States. Table 1 displays demographic descriptors, with 95% confidence intervals, for our sample and the national sample. The difference in age was not statistically significant ($p = 0.334$); aggregate chi-square tests showed significant differences between the two samples for each of the categorical variables ($p \leq 0.003$ for each comparison). However, our sample was similar to the national pool in regard to the following subcategories: those with some college, bachelor's degrees, or master's/doctoral degrees; those with five to seven

years of experience; those who work in large cities or the suburb/fringe of large and mid-sized cities; and those who work for private, county, or military services.

Confidence Level Regarding Anaphylaxis Recognition and Management

With regard to confidence level, 98.0% (3,410/3,479) of the respondents reported that they felt confident in their ability to recognize an adult patient in anaphylaxis. Similarly, 97.1% (3,379/3,479) of those who responded stated they were confident in their ability to manage a patient in anaphylaxis. Also, 96.3% (3,351/3,479) of paramedics stated that they felt comfortable administering epinephrine to an adult patient who is *not* in cardiac arrest.

Recognition of Classic and Atypical Anaphylaxis Presentations

Scenarios were presented in the survey to describe an example of classic and atypical anaphylaxis (see

TABLE 2. Classic and Atypical Anaphylaxis Scenarios Presented to the Paramedic Participants

Classic Scenario

A 24 year-old male calls 911 for itching. On your arrival the patient is talking in 2 word sentences, states his voice sounds different, and that he is itching all over. He states he took a dose of penicillin for a dental infection approximately 20 minutes ago. On your exam, you notice hives, swelling around his lips and face, and diffuse wheezing in bilateral lungs, and that he is sweaty. His blood pressure is 88/52 mmHg, heart rate 120/min, respiratory rate of 32/min, and oxygen saturation of 88%. He is protecting his airway and he is alert and appropriate. He reports no other medications, allergies or past medical history. What do you think is wrong with the above patient? (List up to 3 of your most likely diagnoses) Please be specific.

Atypical Scenario

The county jail calls 911 for a 36 year-old male inmate complaining of dizziness and abdominal pain. On arrival the patient is complaining of sudden onset of severe abdominal pain and cramping for 10 minutes prior to your arrival, accompanied by diarrhea, nausea, vomiting, and dizziness. A nurse in the jail states the patient has had several fainting episodes whenever he tries to stand, but wakes up immediately after being supine. The patient is diaphoretic, incontinent of stool, with a blood pressure of 86/50 mmHg, heart rate of 110, respiratory rate of 28, and oxygen saturation of 88%, pupils are big and reactive bilaterally, mucous membranes are dry, lung sounds are clear bilaterally. His skin is pale, and diaphoretic. His abdomen is soft and non-distended. He also appears to be confused at times. He reports no other past medical history, exposures, allergies to medications or similar episodes in the past. What do you think is wrong with the above patient? (List up to 3 of your most likely diagnoses) Please be specific.

Table 2 for scenarios). The classic example presents suddenly with a known exposure to a common inciting agent (penicillin) and includes the characteristic skin findings of urticaria, itching, and angioedema. The atypical case presents without typical skin findings or known exposure, but mirrors the anaphylactic shock case that was missed by EMS providers described previously¹³ (see Appendix 1 for formal diagnostic criteria for anaphylaxis—available online).

The classic scenario was correctly identified by 98.9% (3,244/3,280) of the respondents. Up to three written responses were allowed, and the question was counted as correct if any one of the responses included the following: anaphylaxis, anaphylactic reaction, anaphylactoid reaction, anaphylactic shock, type I hypersensitivity reaction, allergic reaction, food allergy, or medication allergy.

In contrast, only 2.9% (87/2,958) of the respondents correctly recognized the atypical presentation as anaphylaxis. Numerous other answers were written in, including several intra-abdominal emergencies: Ruptured abdominal aortic aneurysm, appendicitis, and mesenteric ischemia were common diagnoses that paramedics cited. Food poisoning, gastroenteritis, and organophosphate/cholinergic poisoning were common responses as well.

Treatment of Anaphylaxis

Table 3 summarizes the responses gathered regarding the treatment of anaphylaxis, including choice of initial medication to administer as well as the route, location of administration, dosing, and concentration of epinephrine.

Perceived Contraindications to Epinephrine

The respondents were asked the following question: "Are there contraindications to giving epinephrine to

an adult patient experiencing anaphylactic shock?" Of the paramedics who responded, 36.2% (1,059/2,923) stated that there are contraindications to epinephrine administration. The respondents were asked to write in contraindications if they answered "yes" to the above question, and Table 4 summarizes the most commonly reported categories.

Experience with Epinephrine Autoinjectors

A total of 39.5% (1,399/3,537) of the respondents reported working for an EMS agency that carries EAI's in emergency response vehicles, compared with 97.3% (3,442/3,537) stating that their vehicles carry IO devices. In addition, 95.4% (3,318/3,479) of the paramedics responded "agree" or "strongly agree" when asked the following: "I am confident in my ability to correctly administer an EpiPen." Only 32.4% (1,148/3,537) of the paramedics stated they had ever personally administered or assisted a patient with the administration of an EAI. When asked to write in the proper location to administer an EAI to a patient having a severe allergic reaction, 91.7% (2,883/3,144) of those who responded correctly identified the thigh.^{1,15}

Field Experience with Anaphylaxis and Administration of Epinephrine

A total of 83.3% (2,948/3,537) of the paramedics stated they had personally cared for an adult patient experiencing anaphylaxis, and when asked about experience giving epinephrine to patients who are *not* in cardiac arrest (e.g., asthma, anaphylaxis, bradycardia, or hypotension), 28.8% (1,019/3,537) reported that they had given epinephrine to a patient experiencing anaphylaxis, with 47.4% (1,678/3,537) stating they had administered epinephrine to patients for both asthma and anaphylaxis.

TABLE 3. Knowledge Test Items Included in the Survey with Responses Regarding Treatment of Anaphylaxis

1. A 27 year-old male calls EMS for difficulty breathing. On your arrival you find a moderately distressed male sitting at his desk complaining of sudden onset of difficulty breathing, tingling in his throat, face and hands. He also states that he feels light-headed. His vitals are BP of 92/53 mmHg, heart rate 120/min, respiratory rate 30/min with an oxygen saturation of 90%. He has mild wheezing bilaterally in his lungs, his tongue is slightly swollen, but his airway is protected and you notice hives on his chest and abdomen as well. He denies any medical problems. Your partner applies high-flow oxygen. The immediate, initial treatment of choice for this patient is?		
	Percentage (n = 3,040)	
Epinephrine	46.2	(1,403)
Diphenhydramine	40.1	(1,218)
IV fluids	7.7	(235)
Albuterol	5.6	(169)
Corticosteroids	0.3	(8)
Don't know answer	0.2	(7)
2. You are called to the scene of a 35 year-old female patient who just got stung by a bee prior to your arrival. She states that she has severe itching, shortness of breath, and lip swelling. She is wheezing bilaterally, and has hives all over. Her vital signs are all normal. She is protecting her airway and is alert and appropriate. You ask your partner to prepare epinephrine for administration. What route would you give this patient epinephrine?		
	Percentage (n = 2,923)	
SQ (subcutaneous)	58.4	(1,708)
IM (intramuscular)	38.9	(1,136)
IV (intravenous)	1.7	(51)
SL (sublingual)	0.7	(19)
Nebulized/aerosolized	0.1	(3)
Don't know answer	0.2	(6)
3. What location (body part) would you give the epinephrine in the above patient scenario?		
	Percentage (n = 2871)	
Deltoid	60.5	(1,736)
Thigh	11.6	(333)
Thigh or deltoid	3.8	(110)
Abdomen	2.0	(57)
Other/multiple wrong sites	22.1	(635)
4. What dose of epinephrine would you give the patient in question #2 (she is an averaged sized adult approximately 70 kg body weight)? Please write your dose in the blank and include units (i.e.: micrograms, milligrams, grams, units, milliliters, etc. . .)		
	Percentage (n = 2,813)	
Correct dose (0.3 mg)*	83.0	(2,335)
5. What concentration of epinephrine would you give the above patient?		
	Percentage (n = 2,923)	
1:1,000	95.7	(2,796)
1:10,000	4.2	(124)
Don't know answer	0.1	(3)

*Dosage was considered correct if any of the following were stated: 0.3–0.5 mg, 0.3 mg, 0.4 mg, 0.5 mg, 300 mcg, 400 mcg, 500 mcg (0.3–0.5 ml, 0.3 ml, 0.4 ml, and 0.5 ml were counted correct if the respondents answered 1:1,000 concentration in the subsequent question).¹

DISCUSSION

It is difficult to estimate how many patients with anaphylaxis EMS providers may encounter per year in the

United States; and we can find only two studies dealing with the incidence of anaphylaxis in the prehospital setting. One study concluded that roughly 0.5% of all EMS runs in the United States are for allergy-related complaints.¹⁶ After analyzing a large database of EMS calls in multiple states, another study found that approximately 0.4% of all adult calls and 0.5% of all pediatric calls dealt with allergic reactions.¹⁷ Gathering accurate data on the incidence of anaphylaxis is challenging because of inherent underrecognition by health care professionals. However, if these studies' estimates are accurate, with 16.2 million ambulance transports to emergency departments in the United States in 2003, there is the potential that EMS providers may be involved with up to 810,000 patients encounters per year related to allergy/anaphylaxis.¹⁸ Therefore, it is imperative for EMS providers to be able to recognize and appropriately manage anaphylaxis in the field.

TABLE 4. Most Common Perceived Contraindications to Epinephrine

1. Coronary artery disease (including any history of ACS, CHF, or "heart problems")
2. Allergy to epinephrine
3. Tachycardia (including any arrhythmia, SVT, WPW, Vtach)
4. Older age (age cutoff defined anywhere from 35 to 70 years of age)
5. Hypertension
6. Shock/hypotension
7. Pregnancy
8. Glaucoma

ACS = acute coronary syndrome; CHF = congestive heart failure; SVT = supraventricular tachycardia; Vtach = ventricular tachycardia; WPW = Wolf-Parkinson-White syndrome.

This is the first study to comprehensively evaluate a large, national sample of EMS providers on their ability to recognize and manage anaphylaxis. Our results indicate that nearly all respondents (98.9%) were capable of identifying a patient with a classic anaphylaxis presentation. However, when common skin findings such as hives were eliminated (which can occur in up to 10–20% of patients with anaphylaxis) and GI signs and symptoms were incorporated into a scenario (a common finding of food allergy), the rate of recognition dropped to 2.9%.^{1,19} These findings are not all that surprising considering that more highly trained and in-hospital providers may also not recognize an atypical presentation of anaphylaxis.^{3,8,12}

Naturally, the atypical case is a rare presentation, but unfortunately can be just a lethal if not recognized and treated in a timely fashion. There is only one study we could find that could provide some insight into how many cases of anaphylaxis present atypically. Brown performed a large retrospective review of 1,125 patients with anaphylaxis and reported the following incidence of atypical findings: 0.4% with incontinence, 6% with abdominal pain, 10% with vomiting, 3% with diarrhea, and approximately 20% of patients with anaphylaxis had no documented skin findings.¹⁹

There is very little known about the ability of prehospital providers to recognize anaphylaxis in the field. The few studies that have been done are generally small and typically address recognition of classic anaphylaxis presentations. One study attempted to determine how well EMS providers recognized biphasic anaphylaxis. Despite the limitation of having a small number of respondents ($n = 199$) completing the survey and representing just two counties in southeast Michigan, they concluded that both basic and advanced EMS providers had very limited knowledge regarding biphasic anaphylaxis.²⁰ Another study by Lindbeck et al. reviewed 37 EMS calls where epinephrine was given for presumed allergic reactions, concluding that out-of-hospital providers can reliably identify anaphylaxis.²¹ However, in that study nearly all of the patients in the sample presented with rash, swelling, or respiratory problems (i.e., classic anaphylaxis presentations). One study by Rea et al. looked at emergency medicine physician agreement with EMS providers' decisions to administer epinephrine to 22 patients with signs and symptoms of allergic reaction. They found a high level of agreement between physicians and EMS providers' decisions to administer epinephrine.²² However, this was a case-control study and all of the controls (who did not receive epinephrine) were less likely to have had rash and upper airway symptoms. The controls likely represented atypical anaphylaxis, were underrecognized, and therefore not given epinephrine. This would tend to support the findings of our study that EMS providers can reliably recognize classic

anaphylaxis, but have difficulty recognizing atypical presentations.

EMS providers need to accurately recognize both patients who present with classic anaphylaxis and those who present with atypical anaphylaxis in order to administer potentially lifesaving epinephrine. Several small studies have shown that EMS providers are capable of safely administering epinephrine in the field, using both needle/syringe method and EAI, once anaphylaxis is recognized. Fortenberry et al. describe a small case series of patients to whom basic emergency medical technicians (EMT-Basics) administered epinephrine in a wilderness environment for *Hymenoptera* stings without any adverse events.²³ Rea et al. determined that in all 22 cases in which EMS providers administered epinephrine in the field for anaphylaxis, there were no adverse events as well.²² Likewise, Lindbeck et al. reported no adverse outcomes with respect to EMS delivery of epinephrine for anaphylaxis patients in their study of 37 cases.²¹

Regarding knowledge of correct dosing/route of administration of epinephrine in anaphylaxis by EMS providers, one study by Jeong et al. revealed that only 8% and 1% of advanced and basic providers, respectively, knew the correct dose/route of epinephrine for an adult patient. Only 52% of all EMS providers in that study identified epinephrine as the initial medication of choice for the treatment of anaphylaxis.²⁰ Our results indicated that only 46.2% of paramedics, when presented with a classic case of anaphylaxis, correctly identified epinephrine as the initial medication of choice, with 40.1% choosing diphenhydramine as the initial drug of choice. Our survey revealed that the respondents are still more likely to administer epinephrine via the subcutaneous (SQ) route (58.4%) and in the deltoid (60.5%) when given the option, despite years of expert consensus and some research to show that the intramuscular (IM) route given in the thigh is the preferred method of epinephrine delivery.^{1,2,15}

LIMITATIONS AND FUTURE RESEARCH

There are limitations to this study. We initially attempted to study both EMT-Basics and paramedics. In order to detect differences between the two types of providers with a power of 80% and a Type I error rate of 5% (i.e., $\alpha = 0.05$), responses were needed from a total of 3,100 EMS providers (1,550 for each type of provider). The NREMT indicated that their typical national survey response rate was 20–30%. However, our survey was much longer than a typical survey, it had open-ended questions, and we anticipated a lower-than-average response rate of 15%. This required us to send a total of 10,350 surveys of each provider type in order to obtain the necessary 3,100 responses. However, we were unable to get any meaningful

responses from basic providers and therefore continued contacting and analyzing only paramedic providers. Another limitation is that we chose only to address anaphylaxis in adult patients in order to keep the overall number of questions in the survey to a reasonable level. Adding pediatric scenarios and questions about pediatric dosing/route of epinephrine delivery to the survey would make blinding difficult without increasing the length of the survey substantially and would likely have decreased our response rate further. There are several reasons why our results may not be generalizable to the entire EMS population. Respondents may have active certification, but may not be actively practicing. We sampled only paramedics in this survey and did not include other levels of EMS providers such as first responders, EMT-Basics, and EMT-Intermediates because of poor response rates initially, with more basic providers during pilot-testing.

There is no known validated survey instrument that exists to evaluate EMS providers regarding anaphylaxis care, and we had to design our own survey tool. Regarding the atypical anaphylaxis scenario, we made an intentional effort to report the pupils as large and reactive, and mucous membranes as dry, so as not to mislead survey takers toward organophosphate/cholinergic poisoning, which presents with profound diarrhea/vomiting, pinpoint pupils, and copious mucous membrane secretions. We overestimated the number of respondents who correctly identified the classic anaphylaxis scenario for two reasons. Initially, we counted any answer with the word "allergy" in it as correct, including terms like "medication allergy," "allergic reaction," and "drug allergy." However, technically this scenario meets the definition for anaphylaxis as described in the allergy/immunology literature (see Appendix 1—available online).^{1,24} Our percentage of correct responses for the classic anaphylaxis scenario would have dropped substantially from 98.9% to 79.6% had we counted only "anaphylaxis," "anaphylactic shock," "anaphylactoid reaction," "anaphylactic reaction," or "type I hypersensitivity reaction" as correct responses. Another reason for potential overestimation of correct responses regarding anaphylaxis care is that respondents were not proctored, had unlimited time to complete the survey, and thus potentially had reference materials available to them. In the field when a provider cares for someone in an emergency situation, he or she typically has only seconds to minutes to make critical decisions, including what route/dosages of medications to administer to patients.

Another limitation is that this survey may not accurately portray an individual paramedic's knowledge, but rather represents the paramedic's knowledge of his or her local EMS agency protocol regarding anaphylaxis care. If a paramedic's local protocol has instruc-

tions to give epinephrine only to patients with hives, via the SQ route, in the deltoid, and a respondent answers the survey in accordance with the local protocol, then this survey may not necessarily be an indicator of the individual provider's knowledge, but a reflection on the EMS agency.

We were able to contact only those providers with e-mail addresses, and this has an unknown effect on our results. Our sample was randomly selected from providers with e-mail addresses, and although the sample was similar in some demographic data to the national EMS pool, there seemed to be inadvertent oversampling and undersampling of some demographic variables more than others. One explanation for differences between our sample and the national pool is that the NREMT used a different sampling method. They administered a paper-based survey through U.S. mail, which was sent with registration materials for recertification. However, we feel that while differences in demographics were statistically significant, they are likely not clinically relevant. Any self-reported data are always subject to potential recall bias as well. There was no reliable method to measure nonresponders in our study. We had access only to e-mail addresses, and if they did not respond to the multiple requests for survey participation, it was felt by our institutional review board that further attempts at contact could be perceived as harassment by those who refused to participate in this voluntary survey. This, of course, introduces potential nonresponder bias. Also, we chose to use U.S. and American Heart Association consensus guidelines for treatment recommendation regarding dosing of epinephrine, stating that it should be 0.01 mg/kg (up to 0.5 mg), whereas some respondents stated that the correct dose was 0.01 mg/kg and chose to give 0.7 mg of epinephrine to our 70-kg patient, which was counted as incorrect for this survey.^{1,2}

There continues to be a need for more research regarding EMS and anaphylaxis. Ideally, the inclusion of not only classic anaphylaxis, but atypical anaphylaxis would be emphasized in EMS training and incorporated into the national curriculum for all levels of EMS responders. Continuing to reinforce to all health care providers the IM route of administration in the thigh is important as well. There is the potential to further study EMS providers and their ability to care for anaphylaxis patients with high-fidelity simulation such as using ballistics gelatin to simulate administering actual EAI into human tissue.

EMS educators should be informed of EMS providers' commonly reported contraindications/fears of giving epinephrine to patients experiencing anaphylaxis and address them in an evidence-based manner, helping to ensure that epinephrine will not be withheld from a patient because of age, tachycardia, glaucoma, or pregnancy, for example, but emphasizing that there are *no* absolute contraindications

to the administration of epinephrine for patients experiencing anaphylaxis. EMS providers should be assured that epinephrine is indeed safe to administer when in doubt, and if a patient progresses to cardiac arrest as a result of anaphylaxis, the providers will then be administering very high doses of epinephrine (e.g., 1 mg via the intravenous route) multiple times consistent with Advanced Cardiac Life Support protocols. EMS educators and medical directors of EMS agencies need to continue to educate prehospital providers on how anaphylaxis can mimic many other pathologies such as intra-abdominal emergencies and toxic ingestions.

CONCLUSIONS

We report the first study that examines the ability of a large, national pool of EMS providers to recognize and manage anaphylaxis. Our results show that atypical presentations of anaphylaxis are difficult to recognize and that epinephrine is frequently given in the deltoid via the SQ route. We believe this study uncovered some potential deficiencies in anaphylaxis knowledge among EMS providers. Our goal now is to develop a targeted educational intervention that attempts to improve the care EMS providers render to anaphylaxis patients. We encourage further research efforts by others as well aimed at improving prehospital care of anaphylaxis, as it most frequently occurs in the out-of-hospital environment.

References

- Lieberman P, Nicklas RA, Oppenheimer J, et al. The diagnosis and management of anaphylaxis practice parameter: 2010 update. *J Allergy Clin Immunol*. 2010;126:477–80.
- Simons KJ, Simons FE. Epinephrine and its use in anaphylaxis: current issues. *Curr Opin Allergy Clin Immunol*. 2010;10:354–61.
- Thain S, Rubythorn J. Treatment of anaphylaxis in adults: results of a survey of doctors at Dunedin Hospital, New Zealand. *N Z Med J*. 2007;120:U2492.
- Noimark L, Wales J, Du Toit G, et al. The use of adrenaline autoinjectors by children and teenagers. *Clin Exp Allergy*. 2012;42:284–92.
- Nguyen-Luu NU, Ben-Shoshan M, Alizadehfard R, et al. Inadvertent exposures in children with peanut allergy. *Pediatr Allergy Immunol*. 2012;23:133–9.
- Arkwright PD, Farragher AJ. Factors determining the ability of parents to effectively administer intramuscular adrenaline to food allergic children. *Pediatr Allergy Immunol*. 2006;17:227–9.
- Gold MS, Sainsbury R. First aid anaphylaxis management in children who were prescribed an epinephrine autoinjector device (EpiPen). *J Allergy Clin Immunol*. Jul;106(1 pt 1):171–6.
- Grouhi M, Alshehri M, Hummel D, Roifman CM. Anaphylaxis and epinephrine auto-injector training: who will teach the teachers? *J Allergy Clin Immunol*. 1999;104:190–3.
- Kapoor S, Roberts G, Bynoe Y, Gaughan M, Habibi P, Lack G. Influence of a multidisciplinary paediatric allergy clinic on parental knowledge and rate of subsequent allergic reactions. *Allergy*. 2004;59:185–91.
- Kim JS, Sinacore JM, Pongracic JA. Parental use of EpiPen for children with food allergies. *J Allergy Clin Immunol*. 2005;116:164–8.
- Mehr S, Robinson M, Tang M. Doctor—how do I use my EpiPen? *Pediatr Allergy Immunol*. 2007;18:448–52.
- Sicherer SH, Forman JA, Noone SA. Use assessment of self-administered epinephrine among food-allergic children and pediatricians. *Pediatrics*. 2000;105:359–62.
- Jacobsen RC, Gratton MC. A case of unrecognized prehospital anaphylactic shock. *Prehosp Emerg Care*. 2011;15:61–6.
- National Registry of Emergency Medical Technicians Annual Report. Columbus, OH: NREMT; 2010.
- Simons FE, Gu X, Simons KJ. Epinephrine absorption in adults: intramuscular versus subcutaneous injection. *J Allergy Clin Immunol*. 2001;108:871–3.
- Kane KE, Cone DC. Anaphylaxis in the prehospital setting. *J Emerg Med*. 2004;27:371–7.
- Maio RF, Garrison HG, Spaite DW, et al. Emergency Medical Services Outcomes Project I (EMSOP I): prioritizing conditions for outcomes research. *Ann Emerg Med*. 1999;33:423–32.
- Larkin GL, Claassen CA, Pelletier AJ, Camargo CA Jr. National study of ambulance transports to United States emergency departments: importance of mental health problems. *Prehosp Disaster Med*. 2006;21:82–90.
- Brown SG. Clinical features and severity grading of anaphylaxis. *J Allergy Clin Immunol*. 2004;114:371–6.
- Jeong D, Leo H, Cunningham R, et al. Knowledge of biphasic anaphylaxis and treatment for anaphylaxis among EMS providers in southeast Michigan. *J Allergy Clin Immunol*. 2009;123(suppl):S187.
- Lindbeck GH, Burns DM, Rockwell DD. Out-of-hospital provider use of epinephrine for allergic reactions: pilot program. *Acad Emerg Med*. 1995;2:592–6.
- Rea TD, Edwards C, Murray JA, Cloyd DJ, Eisenberg MS. Epinephrine use by emergency medical technicians for presumed anaphylaxis. *Prehosp Emerg Care*. 2004;8:405–10.
- Fortenberry JE, Laine J, Shalit M. Use of epinephrine for anaphylaxis by emergency medical technicians in a wilderness setting. *Ann Emerg Med*. 1995;25:785–7.
- Sampson HA, Munoz-Furlong A, Campbell RL, 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. *Ann Emerg Med*. 2006;47:373–80.

Supplementary Material Available Online:

Appendix 1—Diagnostic Criteria for Anaphylaxis