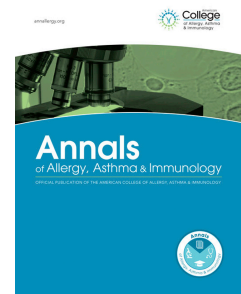


Journal Pre-proof

Use of Electronic Learning Modules Can Improve Medical Trainee Knowledge Regarding Anaphylaxis Diagnosis and Treatment

Erin Rasmussen, M.D., Amanda Grippen Goddard, D.O., Diana Bayer, D.O.



PII: S1081-1206(19)31496-6

DOI: <https://doi.org/10.1016/j.anai.2019.12.018>

Reference: ANAI 3110

To appear in: *Annals of Allergy, Asthma and Immunology*

Received Date: 14 October 2019

Revised Date: 26 November 2019

Accepted Date: 23 December 2019

Please cite this article as: Rasmussen E, Goddard AG, Bayer D, Use of Electronic Learning Modules Can Improve Medical Trainee Knowledge Regarding Anaphylaxis Diagnosis and Treatment, *Annals of Allergy, Asthma and Immunology* (2020), doi: <https://doi.org/10.1016/j.anai.2019.12.018>.

This is a PDF file of an article that has undergone enhancements after acceptance, such as the addition of a cover page and metadata, and formatting for readability, but it is not yet the definitive version of record. This version will undergo additional copyediting, typesetting and review before it is published in its final form, but we are providing this version to give early visibility of the article. Please note that, during the production process, errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

© 2019 American College of Allergy, Asthma & Immunology. Published by Elsevier Inc. All rights reserved.

Use of Electronic Learning Modules Can Improve Medical Trainee Knowledge Regarding Anaphylaxis Diagnosis and Treatment

Erin Rasmussen, M.D.^a, Amanda Grippen Goddard, D.O.^b, Diana Bayer, D.O.^c

^aUniversity of Iowa Hospitals and Clinics

^bNational Jewish Health/University of Colorado Hospital

^cUniversity of Iowa Stead Family Children's Hospital

Corresponding author: Erin Rasmussen

200 Hawkins Drive, Iowa City, IA 52242 USA

Phone: 319-356-1311; Fax: 319-356-8280; Email: erin-w-rasmussen@uiowa.edu

Conflicts of interest: None

Funding source: None

Keywords: Anaphylaxis; allergic reaction; graduate medical education; GME; resident education; electronic learning module

Abbreviations: GME (graduate medical education), PGY (post-graduate year), A/I (allergy/immunology), IM (internal medicine), EM (emergency medicine), FM (family medicine), Peds (pediatrics), Q (question)

Word count: 998

Figures: None

Tables: 1

Anaphylaxis is an acute, life-threatening, systemic hypersensitivity reaction that is frequently underdiagnosed, underreported, and undertreated by medical professionals¹. A recent study by Lindor et al. has shown that medical errors in the setting of anaphylaxis can lead to increased morbidity and mortality. Although the prevalence of anaphylaxis-related hospitalizations has significantly increased over the past 20 years^{2,3}, there remains limited graduate medical education (GME) curriculum dedicated to allergy/immunology (A/I) topics, including anaphylaxis^{4,5}. Electronic learning (e-learning) modules can be incorporated into the GME curriculum to ensure all trainees have access to didactics and offer an alternative to the traditional classroom setting.

Utilizing Articulate Storyline 2® software, a 15-minute e-learning module was created to educate residents on anaphylaxis. This software has been successfully utilized by our institution for medical student and resident educational modules. The interactive module included both a lecture and multiple-choice questions highlighting the definition, clinical presentation, and management of anaphylaxis. Anonymous written questionnaires were completed in-person by pediatric, internal medicine, family medicine, and emergency medicine residents at the University of Iowa prior to watching the e-learning anaphylaxis module during their specialty-specific academic conferences between July 2017 and March 2018. Five weeks later, the same questionnaire was e-mailed to the residents in attendance during the e-learning module, and data was collected anonymously through SurveyMonkey®. Five weeks was chosen as the time point, as this coincided with the 5-week rotating ambulatory clinic cycle.

The pre- and post-module questionnaire consisted of 15 multiple choice questions addressing resident demographics, prior clinical experience treating anaphylaxis, prior completion of an

elective rotation in A/I, and knowledge relating to anaphylaxis diagnosis and management. Data analysis was performed by using SAS software®, version 9.4 (SAS Institute, Inc. of Cary, North Carolina). Statistical methods included simple frequency distributions, two-group t-test for two group comparisons, paired t-test for pre- and post- comparisons within one group, and ANOVA for more than two group comparisons. The study was approved by the University of Iowa institutional review board, and signed informed consent was obtained from all participants.

The most relevant data is reported in Table 1. The pre-module questionnaire and e-learning module were completed by 78 residents of PGY-1, PGY-2, PGY-3, or higher training years. The majority of participants were internal medicine (33%) and pediatric (27%) residents and were in the PGY-1 training year. Only 15% of all residents participating in the module had previously completed an A/I rotation. Emergency medicine residents and those in higher training years had the most prior clinical experience diagnosing and treating anaphylaxis. The post-module questionnaire was completed by 51% of residents who took the pre-module questionnaire. Overall, residents scored significantly higher on the 5-week post-questionnaire than the pre-questionnaire ($p<0.0001$); however, only internal medicine scores were statistically significant ($p=0.002$). Residents in all levels of training improved their scores on the post-questionnaire; however, only PGY-1 and PGY-2 residents had a significant improvement ($p=0.009$ and $p=0.002$, respectively).

Residents with prior clinical experience with anaphylaxis scored significantly higher on the pre-questionnaire (82%) compared to those without experience (76%) ($p=0.04$). Yet, both residents with and without prior anaphylaxis clinical experience, significantly improved their test scores

after the module ($p=0.042$ and 0.0002 , respectively). Residents who completed a prior A/I rotation did not score higher on the pre- and post- questionnaires than those who had not.

Questions regarding epinephrine treatment demonstrated the most significant change in pre- versus post- questionnaire scores. Epinephrine was selected as first-line treatment for anaphylaxis by 92% of participants on the pre-questionnaire and 98% of participants on the post-questionnaire, which was not statistically significant ($p=0.190$).

Our data reveals that residents from all specialties and levels improved their knowledge of anaphylaxis diagnosis and treatment after completion of the e-learning module. Prior to the module, the mean questionnaire score was modest at 80% correct, which may reflect that the test content was not challenging enough.

We found that residents in their first year of training were more likely to participate in the questionnaire and e-learning module, which was likely due to increased attendance during educational conferences. Those in the earlier training years significantly improved their test scores following the module suggesting they had the largest knowledge gap. Based on this, we would recommend that future educational interventions focus on residents early in training.

Internal medicine residents were the only specialty to show a statistically significant improvement following the module which may have been due to their larger number of participants compared to the other specialties.

Furthermore, our results show that baseline knowledge of anaphylaxis was higher in those with prior clinical experience with anaphylaxis, suggesting that those with hands-on experience appear to be more knowledgeable. This has been observed with medical trainees who have

participated in high-fidelity simulation studies, which can also be an effective learning tool.⁶ In contrast, we found that residents who had previously completed a rotation in A/I, did not do better on the pre-module questionnaire than those who had not completed a rotation. We suspect this is due to limited exposure to anaphylaxis in the clinic and suggest increased emphasis be placed on education of anaphylaxis during this rotation.

There were several limitations of this study. The questionnaire was not validated, nor was there a control group who completed the pre- and post-module questionnaire without watching the module. The post-test questionnaire was completed 5 weeks after completion of the electronic module, and it may have been beneficial to evaluate longer term acquisition of knowledge. In addition, only 51% of residents completed the post-module, decreasing the power of our study. It is also not known whether those residents who did not complete the 5-week questionnaire differed in terms of knowledge. This was a single academic center study, and it may be beneficial to compare the results of community-based residency programs as well.

Anaphylaxis e-learning modules result in knowledge acquisition and retention for a diverse group of trainees. Widespread use of this learning method for anaphylaxis education can improve trainees' ability to recognize, diagnose, and treat this potentially life-threatening condition.

- 1 1. Aun MV, Kalil J, Giavina-Bianchi P. Adults and children with anaphylaxis in the
2 emergency room: why it is not recognized? *Curr Opin Allergy Clin Immunol* 2018;18:377-
3 381.
- 4 2. Mullins RJ, Dear KB, Tang ML. Time trends in Australian hospital anaphylaxis admissions
5 in 1998-1999 to 2011-2012. *J Allergy Clin Immunol* 2015;136:367-375.
- 6 3. Turner PJ, Gowland MH, Sharma V, Ierodiakonou D, Harper N, Garcez T, et al. Increase in
7 anaphylaxis-related hospitalizations but no increase in fatalities: an analysis of United
8 Kingdom national anaphylaxis data,1992-2012. *J Allergy Clin Immunol* 2015;135:956-
9 963.e1.
- 10 4. Adeli M, Hendaus MA, Abdurrahim LI et al. The importance of educating postgraduate
11 pediatric physicians about food allergy. *Adv Med Educ Pract* 2016;19:597-602.
- 12 5. Cohen MB, Saunders SS, Wise SK et al. Pitfalls in the use of epinephrine for anaphylaxis:
13 patient and provider opportunities for improvement. *Int Forum Allergy Rhinol*
14 2017;7:276-286.
- 15 6. Pfeifer K, Staib L, Arango J et al. High-Fidelity Contrast Reaction Simulation Training:
16 Performance Comparison of Faculty, Fellows and Residents. *J Am Coll Radiol*
17 2016;13:81-87.

Table 1

Resident demographics and questionnaire results pre- and post-anaphylaxis module

	Prior A/I rotation (pre-module)		Prior anaphylaxis clinical experience (pre-module)		Participants pre-module		Participants post-module		Mean pre-module questionnaire score	Mean post-module questionnaire score	P value
Overall	12	(15%)	47	(60%)	78	(100%)	40	(100%)	80%	88%	<0.0001
Training year											
PGY-1	4	(13%)	12	(39%)	31	(40%)	17	(43%)	77%	86%	0.009
PGY-2	5	(21%)	15	(63%)	24	(31%)	15	(38%)	79%	90%	0.002
PGY-3+	3	(13%)	20	(87%)	23	(29%)	8	(20%)	84%	89%	0.296
Specialty											
IM	5	(19%)	16	(62%)	26	(33%)	14	(35%)	78%	89%	0.002
EM	1	(6%)	12	(75%)	16	(21%)	12	(30%)	82%	87%	0.282
FM	2	(13%)	8	(53%)	15	(19%)	7	(18%)	83%	90%	0.125
Peds	4	(19%)	11	(52%)	21	(27%)	7	(18%)	78%	87%	0.069
A/I rotation											
Prior Rotation					12	(15%)	5	(13%)	80%	90%	0.079
No Prior Rotation					66	(85%)	35	(88%)	80%	88%	0.0003
Anaphylaxis clinical experience											
Prior Experience					47	(60%)	17	(43%)	82%	88%	0.042
No Prior Experience					31	(40%)	23	(58%)	76%	89%	0.0002
Anaphylaxis questionnaire*											
Q1-Timing of anaphylaxis symptoms					78	(100%)	40	(100%)	77%	88%	0.170
Q2-Description of anaphylaxis symptoms					78	(100%)	40	(100%)	94%	98%	0.300
Q3-Recognition and treatment of anaphylaxis					78	(100%)	40	(100%)	92%	98%	0.190
Q4-Location for epinephrine injection					78	(100%)	40	(100%)	88%	100%	0.002
Q5-Monitoring time in ED following anaphylaxis					78	(100%)	40	(100%)	45%	63%	0.070
Q6-Epinephrine treatment in adults					78	(100%)	40	(100%)	78%	93%	0.026
Q7-Epinephrine treatment in children					78	(100%)	40	(100%)	87%	88%	0.960
Q8-Frequency of re-dosing epinephrine					78	(100%)	40	(100%)	41%	60%	0.050
Q9-Description of biphasic reaction					78	(100%)	40	(100%)	97%	100%	0.159
Q10-Prescription medication upon ED discharge					78	(100%)	40	(100%)	96%	98%	0.710

A/I, Allergy and immunology; IM, internal medicine; EM, emergency medicine; FM, family medicine; Peds, pediatrics; Q, Question

*Full anaphylaxis questionnaire can be found online as e-supplementary data

We are grateful to Yubo Gao, PhD for his assistance with the biostatistical computations for this manuscript. We also want to thank Manish Suneja, MD for his assistance with creating the Articulate Storyline anaphylaxis module.

Anaphylaxis Questionnaire

Demographics:

1. What is your specialty?
 - a) Pediatrics
 - b) Family medicine
 - c) Emergency medicine
 - d) Internal medicine
 - e) Med-Psych
 - f) Family Med-Psych
2. What is your level of training?
 - a) PGY-1
 - b) PGY-2
 - c) PGY-3
 - d) PGY-4
 - e) PGY-5
 - f) Other: _____
3. Have ever had clinical experience diagnosing and treating anaphylaxis?
 - a) Yes
 - b) No
4. Have you ever completed a clinical rotation in the field of Allergy-Immunology?
 - a) Yes
 - b) No
5. Are you aware of the UIHC anaphylaxis action plan in Epic?
 - a) Yes
 - b) No

Quiz:

1. When do symptoms of anaphylaxis occur?
 - a) Within minutes after exposure to an allergen
 - b) Within hours after exposure to an allergen
 - c) Within days after exposure to an allergen
 - d) A & B**
2. Which of the following signs and symptoms can patients with anaphylaxis present with?
 - a) Angioedema
 - b) Diarrhea
 - c) Syncope
 - d) All of the above**
3. A 27 yo F presents to the ER with wheezing, shortness of breath, and urticaria. Which of the following should be used first to treat the patient's symptoms?
 - a) Antihistamines
 - b) Epinephrine**
 - c) Corticosteroids
 - d) Nebulized albuterol/ipratropium
4. What is the preferred site of injection for epinephrine?
 - a) Lateral thigh**
 - b) Lateral upper arm
 - c) Buttocks
 - d) Abdomen

5. Subsequent to an anaphylactic reaction, how long is recommended for a patient to be monitored prior to discharge from an emergency department?
- a) 1 hour
 - b) 4 hours**
 - c) 6 hours
 - d) Must be admitted to hospital for observation
6. What is an appropriate dose and route of epinephrine in adults with anaphylaxis?
- a) 0.15 mg; Subcutaneous
 - b) 0.15 mg; Intramuscular
 - c) 0.3 mg; Subcutaneous
 - d) 0.3 mg; Intramuscular**
7. What is an appropriate dose and route of epinephrine for a 15 kg child with anaphylaxis?
- a) 0.1 mg; Subcutaneous
 - b) 0.15 mg; Intramuscular**
 - c) 0.25 mg; Subcutaneous
 - d) 0.3 mg; Intramuscular
8. How frequently may epinephrine be re-dosed?
- a) Every 1 to 5 minutes
 - b) Every 5 to 15 minutes**
 - c) Every 15 to 30 minutes
 - d) Every 30 minutes to 60 minutes
9. What is a biphasic reaction?
- a) Symptoms of anaphylaxis presenting in 2 different organ systems
 - b) Symptoms of anaphylaxis lasting longer than 2 hours
 - c) Anaphylaxis as a child and as an adult
 - d) Complete resolution of signs and symptoms of anaphylaxis with recurrence of symptoms up to 12 hours later**
10. Following an episode of anaphylaxis, which prescription medication should patients receive on discharge from the emergency department?
- a) Epinephrine autoinjector**
 - b) Diphenhydramine
 - c) Cetirizine
 - d) Oral corticosteroids