Failed Knowledge Retention from Educational Intervention on Anaphylaxis Management Among Medical Personnel

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Abstract:
Background: Anaphylaxis is a life-threatening allergic reaction that is often inadequately treated in the hospital setting, leading to adverse outcomes. We hypothesize that a brief educational intervention will enhance knowledge of community-based medical professionals evaluated by pre- and post-questionnaires, leading to improved recognition and management of anaphylaxis.

Methods: An initial questionnaire consisting of eight multiple-choice questions and two fill in response pertaining to anaphylaxis identification, management, and treatment was completed by 189 University Hospitals Regional Hospitals personnel, including faculty, nurses, student, residents, and Emergency Medical Services (EMS). The participants were then offered an educational intervention, including a 10-slide, 20-minute PowerPoint presentation on anaphylaxis, and review of the pre-educational intervention questionnaire responses, followed by a post-educational intervention questionnaire similar to the initial questionnaire. Seventy-seven participants completed the same questionnaire at a six-month follow-up to assess retention.

Results: Participant scores improved from 62% to 94%, from the initial questionnaire to the immediate post-educational intervention questionnaire. The six-month post-educational intervention questionnaire revealed a return to near baseline (65%) medical knowledge regarding anaphylaxis.

Conclusion: Healthcare personnel demonstrate a knowledge deficit of identification and management of anaphylaxis. In the short-term, a brief, educational intervention did improve knowledge of anaphylaxis (p<0.00001). However, in the long-term, this educational intervention did not improve knowledge retention about anaphylaxis (p=0.52218). We received approval for and implemented an anaphylaxis order set in the electronic medical record (EMR) at University Hospitals, in effort to improve patient care.

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Introduction:
Anaphylaxis is an acute, life-threatening systemic reaction with varied mechanisms, resulting in varied clinical presentations and severity from the sudden systemic release of mediators from mast cells and basophils.1 There are no absolute contraindications to the administration of epinephrine in the treatment of anaphylaxis and delays in its administration may lead to increased morbidity and mortality. Despite these facts, studies continue to demonstrate delays and avoidance of epinephrine administration by medical personnel.23 Morbidity and mortality reports for the allergy/immunology fellowship consult cases at regional sites throughout a large, university and
community hospital setting have identified educational opportunities for licensed physicians, doctors-in-training, nursing, emergency medical service personnel (EMS), and pharmacists, to improve recognition, treatment, preparedness, and comfort with administering epinephrine.4,5

A population-based incidence study of anaphylaxis by Lee et al. reported an age- and sex-adjusted incidence rate of 42 out of 100,000 people, with an average increase of 4.3% per year.6 Anaphylaxis fatality rates among hospitalizations or emergency presentations were between 0.25% to 0.33% in a population-based epidemiological study by Ma et al. Despite numerous publications spanning over several decades, there is a reported and observed reluctance in initiation of epinephrine early and correctly in the clinical course.

A whole-system approach is required to elucidate reasons for resistance to adhering to evidence-based practices. We hypothesized that increasing familiarity in the expected effects of epinephrine administration, its location in the hospital, and recognition/education of anaphylaxis by EMS will result in the hospital staff being better prepared to treat life-threatening anaphylaxis in a more efficient and timely manner. This study aimed to develop methods to close knowledge gaps among medical professionals leading to improvement in patient care.

Methods:
The present study was approved by University Hospitals IRB (NHR-17-27). The investigators developed a ten-item pre-educational intervention questionnaire reflecting study participants’ previous overall knowledge of the presentation and treatment of anaphylaxis (Table1). A subsequent educational intervention was developed reviewing the knowledge in the initial question set. A similar post-educational intervention questionnaire but not identical, of ten questions was developed by the investigators as well.

The educational intervention and pre- and post-questionnaires were administered by a student volunteer and an allergy/immunology fellow to the medical staff in-person. This allowed us to engage the medical staff in a dialog concerning issues surrounding anaphylaxis knowledge and treatment. These medical professionals were from the emergency room, general medical units and intensive care units of a community-based hospital system. Each medical professional completed the session within 20 minutes. Upon completion of this session, each medical professional received a nominal gift card for appreciation.

| Table 1: Anaphylaxis Questionnaire |
|-----------------------------------|
| 1. True/false: Methylprednisolone and diphenhydramine used early will stop the progression of anaphylaxis. |
| 2. Symptoms of anaphylaxis will most likely occur… |
| 3. Which of the following are least likely to cause anaphylaxis overall? |
| 4. Signs and symptoms of anaphylaxis can include which of the following? |
| 5. True/false: Epinephrine should be given early in anaphylaxis. |
| 6. True/false: If a patient developed mild rash within minutes of consuming peanuts, then he will always develop this same reaction every time he eats peanuts. |
| 7. Epinephrine for anaphylaxis should be administered… |
| 8. True/false: A patient with anaphylaxis has IV access. The preferred administration for epinephrine should be IV. |
| 9. The proper dosing of epinephrine is… |
| 10. Name up to 3 locations in which your respective location where you can find 1 mg/1 mL epinephrine for IM injection if emergently needed |

IV = intravenous, IM = intramuscular

Six-months later, this same intervention was re-administered to the same population of medical professionals. The Student t-test was used for pre and post-educational intervention questionnaire test scores both immediately and 6 months after education was provided. An ANOVA on association between medical staff profession scores with a Dunn’s multiple comparison test was performed. Statistical analysis was performed using GraphPad 9 and with 95% confidence levels.

Results:
A total of 189 medical professionals of the University Hospitals of Cleveland community
medical centers completed the educational intervention and initial questionnaires. The study participants consisted of 16 attending physicians, 51 residents, 31 medical students, nine EMS and 91 nurses (Figure 1).

**Figure 1: Pre-educational intervention questionnaires scores**

![Pre-educational intervention questionnaires scores](image)

Refer to Table 1 for Anaphylaxis Questionnaire item text. ANOVA: Kruskal-Wallis test with Dunn’s Multiple comparisons test.

A total of 77 participants completed the six-month retention assessment. Participant scores improved from 62% to 94% correct in the short-term (p<0.00001). Attending physicians had the highest baseline scores averaging 68% correct with an improvement to 95% correct after the educational intervention. Medical students had the lowest baseline scores averaging 59% correct with an improvement to 91% correct after the educational intervention. The question most commonly answered incorrectly was for the proper dosing of epinephrine for the treatment of anaphylaxis (Figure 2). The six-month post-educational intervention questionnaire revealed a return to near baseline (65%) medical knowledge regarding anaphylaxis (p=0.52218).

**Figure 2: Anaphylaxis management knowledge pre- versus post-educational intervention.**

![Anaphylaxis management knowledge pre- versus post-educational intervention](image)

Percentage is given in questions answered correctly. Anaphylaxis questionnaire performance of medical professionals immediately before (62%) and after (94%) and then six-months later (65%).

**Discussion:**

Proper identification and management of anaphylaxis continues to be a challenge for medical professionals. Epinephrine is the only medication to which there are no absolute contraindications in administration for anaphylaxis, and delays in administration leads to increased mortality. Despite these facts, studies, and reports from consult cases throughout the hospital system, there continues to be a delay in anaphylaxis recognition and treatment, as well as a lack of preparedness and comfort with administering epinephrine by medical personnel.

Baseline knowledge among medical professionals for the identification and management of anaphylaxis was established via a questionnaire, and a brief educational intervention led to a significant improvement in knowledge of anaphylaxis in the short-term. However, implementation of the educational intervention did not demonstrate retention of this knowledge after six months had lapsed.

Our analysis of each pre-educational intervention questionnaire item elucidated notable findings (Figure 1). Responses to Questions 1, 4, and 6 suggested that more years of experience correlated with identification of the correct solution among multiple choice options. However, these more experienced health care personnel did not consistently identify and present therapeutic knowledge about anaphylaxis.

The significance of early epinephrine administration during anaphylaxis is a well-
established clinical guideline, supported by observational studies, extrapolation from retrospective case reports, and limited clinical trials. Our evidence suggests this does not transfer into actual practice. There appears to be discordance between these two points. This suggests that there is a false positive behavioral reinforcement occurring based on anaphylactic episodes resolving after the administration of antihistamines and steroids (Figure 3). In its entirety, the false positive behavioral reinforcement may explain the difficulty in learning to treat anaphylaxis based on the best evidence and practices available. It is not possible to predict a self-resolving anaphylactic episode from one that will lead to mortality in order to ethically differentiate whether antihistamines and steroids averted mortality.

Question 1 focused on the identification of anaphylaxis (Figure 1.a.). A statistically significant difference was observed between the medical student and resident physician groups versus the attending physician and nurse groups of participants for six questionnaire items (Figure 1.a., p=0.011). While a direct cause-and-effect relationship cannot be definitively established, it is suggestive that clinical experience, with more patient encounters involving anaphylaxis, may lead to early identification of the clinical presentation of anaphylaxis.

Question 2 tested the accurate diagnosis of anaphylaxis (Figure 1.b.). A knowledge gap in the diagnosis of anaphylaxis was observed among all medical professionals with fewer than 50% of medical professionals answering this question correctly.

The most common etiology of anaphylaxis, tested by Question 3 (Figure 1.c.), was correctly identified by approximately 50% of medical professionals. A statistically significant difference was not observed among each group of medical professionals (Figure 1.c., p=0.762).

Notably, Question 4 was concerning the prognosis of hypersensitivity reactions and anaphylaxis (Figure 1.d.). A linear improvement in scores from nursing staff and physicians as they progress through training was observed (Figure 1.d., p=0.0001). Linear improvement in scores as physicians progress through training suggest education and/or experience leads to a stronger understanding of the prognosis for anaphylaxis.

Question 5 focused on the clinical outcome of anaphylaxis (Figure 1.e.). All medical professionals, with the exception of EMS, correctly knew that early administration of epinephrine for anaphylaxis leads to better outcomes. EMS is the first responders to patients and would be the most appropriate group to administer epinephrine early in the course of anaphylaxis. EMS often do not see the outcome of their patients once they reach the ER. Nurses and physicians, even those in training, often provide care to the same patient for a prolonged period of time compared to EMS, and are more likely to see the importance of administering epinephrine early in the course of anaphylaxis. It should also be noted that the number of EMS within our study group was the lowest. Therefore, this may also account for the overall significance of missed questions within this group.

The observations seen for Question 5 also applies to the asymptotic linear regression seen for Question 6 (Figures 1.e. and 1.f.). The patterns seen for Question 6 and 7 are possibly explained by the same reasoning cited for Question 5 (Figures 1.e.-1.g). Secondary to the variance in answer choices for Question 7 (Figures 1.g.), there was much discussion and debate, as health care providers indicated that in textbooks and review material, subcutaneous and intravenous routes of administration were considered standards of care. This led to further investigations where books used for board review had discrepancies in proper treatment.

Questions 8 and 9 focused on the proper route of administration of epinephrine in the setting of anaphylaxis (Figures 1.h. and 1.i). The graph patterns for each of these questions were relatively similar with the exception of the EMS group (Figures 1.h. and 1.i). This finding may reflect the consistency of knowledge among each group of medical professionals as well as specific knowledge area their questions tested. In Question 8 (Figure 1.h), the data is consistent with the notion that the further one is from medical school education, the more likely that there could be a lapse in current knowledge.

Question 9 (Figure 1.i), opposed to the others, clearly indicated an equal disparity in knowledge of epinephrine dosages, which emphasized the need for intervention on the end of the investigators. The results demonstrated a brief, learning module did improve the knowledge in the
identification and management of anaphylaxis, with the questionnaire scores increasing from 62% correct before to 94% immediately after the educational intervention (Figure 2, p<0.00001).

The question most frequently answered incorrectly was regarding the proper concentration and route of administration of epinephrine for the treatment of anaphylaxis. During our long-term post-educational intervention questionnaire debrief with participants, we identified several recently published textbooks and review resources that depict epinephrine dosing and routes of administration contradictory to the standard of care. Out of professional respect, the identified resources are intentionally withheld but will be furnished upon request. We suggest implementation of a task force or committee to coordinate and standardize anaphylaxis care throughout the medical educational literature.

Our findings indicate a decline in questionnaire scores over a six-month time period. From this, we proposed and developed an updated anaphylaxis order set within the EMR system (Table 2). This standardized order set was designed to auto populate the definition of anaphylaxis, correct epinephrine dose (i.e. IM 0.01 mg/kg of 1 mg/mL solution, 0.5 mg adults, 0.15 mg children), concentration, and route of administration to help standardize medical management and prevent reference to inconsistent sources when recollecting prior medical knowledge, as suggested by our questionnaire intervention. This would minimize future morbidity and mortality caused by the improper recognition and management of anaphylaxis.

Table 2: Anaphylaxis order set quality improvement measures

|                | Former | Updated |
|----------------|--------|---------|
| Epinephrine as first-line treatment | Epinephrine not clearly specified as treatment of choice. | Epinephrine clearly specified as first-line, separate from second line, with no absolute contraindication. |
| Epinephrine dose | Multiple administration routes, including IM and IV. | Only option of weight-based IM dosing. |
| Adjuvant therapies | Not clearly labeled as second line. | Clearly specifies second line. |
| Anaphylaxis diagnostic criteria | No criteria included. | Criteria included. |
| Glucagon indication | Not included. | Clearly stated. |

Information was presented in the order set and not as a pop-up warning/information.

Conclusion:
An updated anaphylaxis order set reflective of current standards by the Joint Task Force on Practice Parameters for Allergy & Immunology will serve as a tool for appropriate management of anaphylaxis once identified. From a medical education standpoint, a brief educational intervention is inadequate to maintain medical standards and sufficiently prepare for potential medical emergencies. The development of an order set would offer a solution, with appropriate implementation and widespread awareness, in order to enhance the quality of care.

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JJ, TA, MS, BP, and RH contributed to the conception and design of the work. GR, CK, BL, and SL acquired and analyzed the data. JJ, TA, MS, MR, BP, and RH participated in the drafting and critical revision of the manuscript. All authors approved the final version of the manuscript to be published.

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