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PERSPECTIVES

A Conceptual Framework for Instructional Design of a High Acuity and Low Occurrence Event - Simulation Based Education Training of Residents, Medical Students, and Nurses in Anaphylaxis Utilizing Curated Educational Theories

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Abstract: The broad goal of this educational curriculum is utilization and optimization of Simulation-Based Education (SBE) in the training of residents, medical students, and nursing staff involved in the rapid and timely recognition of Anaphylaxis and its optimized treatment. A critical gap in Anaphylaxis Diagnosis, Management, and Treatment (ADAM) has been well established across medical disciplines. It is imperative to include all members of the healthcare team, as nurses and pharmacists play key roles in anaphylaxis recognition and care. Nurses and pharmacists are proficiently trained in the initial assessment of acute patient complaints, status, and in proper dosing/administration considerations. Anaphylaxis is a High Acuity and Low Occurrence (HALO) event. Delayed recognition and administration of epinephrine-autoinjector (EAI) is a patient safety concern. Suboptimal technique and expertise in this regard is common. Literature abounds with reports of physician trainee doubts and uncertainties in the recognition and optimized management of Anaphylaxis. Importantly, Anaphylaxis is frequently misdiagnosed in hospital emergency departments. SBE methodologies are ideal for instructing HALO experiences. The framework of the "Zone of Simulation Matrix" supports the utilization of a simulation experience in this instance. Learning will be effective, enhanced, and made durable by embedding numerous specifically curated educational theories. Given the paucity in training of residents and nursing staff in Anaphylaxis, such instruction is imperative. Of note, a special emphasis in this curricular framework is the debriefing experience. Considerations will be given to the psychological safety of the trainees and the importance of the heterogeneity of prior experiences. Precise diagnosis minimizes mortality. In the hospital setting, nurses are the first responders to critical HALO events, and there is a lack of awareness of ADAM by nursing students.

Keywords: simulation based education, anaphylaxis, resident, nurse and medical student education, debriefing, epinephrine autoinjector, HALO events, zone of proximal development, zone of simulation matrix

Introduction

At 1 pm, on Sunday June 23, 2019, Air Canada Flight AC 538, an Airbus 320 twin engine aircraft with 112 passengers on board departed Vancouver International Airport (YVR). Halfway through the flight en route to Anchorage, Alaska, an

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engine shutdown developed, and the aircraft returned safely to YVR.[1] Pilots undergo simulation training for engine shutdown and other critical aviation related HALO events methodically. SBE has had its origins in aviation training. In a similar analogy, a physician may complete a residency training in internal or emergency medicine, or a fellowship in critical care medicine without seeing various HALO events, if any. There is a scarcity of ADAM in the training of Medical Students and Nurses as well.

Managing HALO events such as ADAM are expected skill sets of the graduates of these training programs. High Fidelity simulation training of residents, students and nurses can ensure safe and competent patient care in infrequent presentations. Moreover, presentation of a HALO event in an in situ simulation, can provide meaningful deliberate practice and hone skill sets.[2] The construct of deliberate practice champions relentless practice to identify domains needing improvement by expert coaching and feedback. Recognition and management of ADAM is challenging for physicians.[3] Effective interventions are needed to improve physician knowledge and competency in ADAM.[3] Knowledge gaps of medical students in Anaphylaxis resuscitation have been documented.[4] The non-optimized diagnosis and recognition of anaphylaxis remains to be a known knowledge and skill deficit in medical education.[5] SBE practices are ideal for instructing HALO experiences. An additional benefit in this curriculum is promotion of interprofessional education as well.[6] The framework of the "Zone of Simulation Matrix" supports the utilization of a simulation experience in this instance.[7] Chiniara et al have developed a taxonomy for instructional design that favors the utilization of an SBE context for HALO experiences.[7] In this "Zone of Simulation Matrix" other HALO events can be added as well. The incorporation of SBE for instructing medical students and residents in "allergic and immunologic emergencies" is encouraged.[8] Patients with Anaphylaxis are critically ill. SBE is superior to didactics and is the preferred educational system for teaching senior medical students its diagnosis and treatment.[9] Training for HALO events is emerging.[10] Durability and retention of the resident skills in ADAM is further enhanced by simulation.[11] Institutions implementing this conceptual framework, when appropriate, should seek approval from their departmental curriculum committee.

Curricular Learning Outcomes

All curricula start with intended learning outcomes. It is suggested that for this ADAM curriculum, at the conclusion of the learning experiences, the trainees will be able to:

1. Recognize Anaphylaxis.
2. Obtain a rapid and focused medical history, ask about any previous similar episodes (déjà vu), and if patient has self-injected with EAI.
3. Perform a rapid physical examination with special emphasis to ABCDEs and presence of skin involvement.
4. Institute medical care by addressing the underlying cause, administering oxygen, verifying the presence of a patent airway and intubate if indicated. Initiate establishment of two large bore IV lines, and select prioritized therapeutic agents.
5. Partner collaboratively with other members of the care team (pharmacists, respiratory therapists, nursing students, and senior physicians) to achieve positive outcomes and attenuate the anaphylactic response.

Instructional Design and Educational Theories

Instructional design of any curricular process needs to address the alignment of the learning outcome to the appropriate teaching methodology. HALO event Instructional Design for Anaphylaxis must incorporate action-based trainee engagement.[12,13] At the core of this Instructional Design process, the application and integration of educational theories will enhance the learning process. Training in HALO events augments patient safety and importantly, learning is enhanced by creating Desirable Difficulties(DD) in the case scenarios.[14,15] Creation of DD interlaces favorably with Vygotsky's Zone of Proximal Development (ZPD).[16] Consequently, trainees need not be unnecessarily bored with the experience. Tasks in the ZPD are those that the learner can only do with coaching and scaffolding. In the ZPD, trainees are near to mastering the skills, given optimized coaching. Vygotsky claims that all learning occurs within the ZPD.[16] In a phenomenological study conducted by Groot et al, it was noted that simulation experiences at the ZPD's frontier gives rise to stress; and stress assuaging interventions ameliorate the experience.[17] In the ZPD as applied to experiential learning, HALO event learning

mandates SBE. Mihaly Csikszentmihalyi is the creator of "flow theory" and has described its unique exultation while trainees are in the "flow zone".[18,19] Facilitators in the Anaphylaxis simulation session need to be aware that scaffolding is essential to reduce cognitive load and embedding the trainees in the flow channel so that learning in the ZPD while anxiety-provoking, is enjoyable as well. Other applicable educational theories to experiential learning will be discussed herewith.[20]

Flipped Classroom and Case-Based Collaborative Learning

Flipped Classroom learning is a nascent landscape that can provide an engaged, optimized, and impactful approach to the Instructional Design of an ADAM curriculum.[21] Flipped Classroom learning is an andragogical approach that learners study before class and apply the learned concepts in facilitated small group activities.[22] Utilizing a modified Flipped Classroom and methodologies of Case Based Collaborative Learning, one week prior to the start of the experience, trainees will be given faculty designed content on ADAM.[22–24] Furthermore, this content will include an instructional video on the administration of "Epinephrine Auto Injector" (EAI). Learners will take a formative self-assessment learning check prior to attending the Flipped Classroom event. This approach enhances active learning and trainee engagement. While attending class, trainees in small groups of six will engage in application of knowledge, reviewing a case and answering questions, facilitated by simulation instructors.

Strategies for the Reduction of Cognitive Load (CL)

This SBE curriculum will start by applying the concepts of reducing CL. Reduction of the CL in simulation experiences is paramount.[25] Subsequent to the Case Based Collaborative Learning session, the trainees will be scheduled for a tour of the Simulation Center and familiarity with the manikin. A Cognitive Aid manual such as the spiral bound "Stanford Emergency Manual for Perioperative Critical Events (SEM)" can be attached to the crash cart of the simulation (SIM) room.[26] SIM instructors can easily eliminate extraneous loads for the trainees. An example would be minimizing monitor bells. It should be noted that trainees do best by learning with technology and not from it. Importantly, scenario design and layout can assuage CL.[27]

Pre-Brief Experience

On the scheduled day of the experience, trainees will attend a pre-brief session. The pre-brief will discuss: Psychological Safety, Learning Objectives, duties of the participants and facilitator(s), suspension of disbelief, and an additional orientation to the learning milieu. A checklist for the Event Manager and Facilitators is available from the British Columbia Simulation Network.[28] Confidentiality is discussed in the pre-brief session. Role assignment of the trainees can be utilized for efficiency.[29] Teams generally consist of six trainees (including the scribe).

Scenario and Simulation Room Experience

A simulation-based scenario in Anaphylaxis has been developed by McCoy and can be utilized in this curriculum.[30] The scenario is comprehensive and can be adapted to the unique needs of each institution. A checklist/worksheet should be utilized to customize the scenario. Scenario design templates are available.[31] Following the pre-brief, participants will be led to the SIM Room with a nurse (confederate) in attendance of the patient (manikin). This is a case of a young male who presented to the ED with what appears to be a Restaurant Syndrome.[32] The manikin should be pre-programmed to the algorithms in the scenario. A critical step in the case involves obtaining/reviewing the pertinent history, which is having eaten Chinese food that had been cooked in peanut oil. Once physical examination is performed and Anaphylaxis is recognized, critical and appropriate management will commence. Trainees should have learned all of the critical steps in the pre-work content and videos prior to the experience.

The Debrief Terroir – Transcending a Generic "Good Job" into an Individualized, High-Quality, Multimodal and Impactful Learning Experience

Debriefing is an important aspect of active learning. When done correctly, it closes the learning gap, provides durability to the learning process, and improves future performance. Explicit trainee observation steers meaningful feedback.[33] Supportive statements such as "good job" do not augment learning.[33] Application of Kolb's Experiential Theory is

particularly useful in this ADAM debrief experience.[34,35] According to this educational theory, deep learning is potentiated by experiences. SIM experiences have the likelihood to provide the needed experience for trainees. Applying Kolb's Experiential Theory to this SIM experience, the SIM session is the "Concrete experience" (what happened?). The "Reflective Observation" is about thinking (what did I experience?). The "Abstract Conceptualization" is about the case scenario analysis and discussion (why did this happen?). The final phase of the said theory, "Active Experimentation" will be experienced by trainees in a different case scenario or in patient care. Learners can enter the cycle at any stage. Participants will establish a "shared mental model", thus envisaging and predicting the actions of the other team members.[36,37] The four constituents of Kolb's Experiential Learning Theory are mappable to the expected trainee competencies in patient care and provide the facilitators with an effective instruction tool.[38]

Active trainee engagement is the key tenet of the debrief session, it augments learning.[39] Participants are encouraged to be fully engaged in this process. Low frequency participants will be encouraged by the facilitators to engage with deliberate probing. A psychologically safe session ensures trainee participation. The session should be referenced to the key learning objectives of the scenario. Importantly, the curricular learning outcomes provide guidance for an optimized debrief experience.[40] The session should be trainee-centered, and facilitators should let them drive the deliberation. Debriefers should focus on minimizing the culling of small details by trainees, shepherding them to uncover and explore the big picture versus the minor performance issues.[41] Numerous methodologies exist for debriefing, and one in particular the "Advocacy/Inquiry" methodology by Rudolph et al, is impactful.[42]

Trainee participation and engagement in a team SIM experience is complex, and the debrief facilitators should select a blueprint that sustains "adaptive performance".[43] Evolving patient status/deterioration in Anaphylaxis is an example that mandates adaptive mastery. Facilitators need to be cognizant of the heterogeneity of prior knowledge/learning/experience of the trainees while discussing/intervening in the debrief discussions.

Framework for Formative Curricular Assessment and Outcome Measurements

In any curricular design process, learning outcomes must align with assessment.[13] Importantly, to the dismay of medical educators, "assessment drives learning".[44,45] The significance of formative assessment lies in its effectiveness in assisting both the trainees and medical educators in identifying and correcting learning gaps in a timely and specific approach. Formative evaluation is "assessment of learning".[46] In this curriculum, trainees will be assessed at various stages: the pre-test, post-test, participation in the SIM experience, discussions with peers/facilitators, and in the debrief experience. Prior to the simulation experience, learners will partake a 20-item knowledge-based multiple-choice question (pre-test) related to the learning objectives and content provided to them. This will utilize the educational theory of Constructive Alignment. In Constructive Alignment, emphasis is on the synergy of goals, outcomes, assessment, and content.[47] Moreover, additional qualitative questions will address the learners' confidence in managing Anaphylaxis, comfort in using the EAI and the barriers that they have encountered in treating patients with Anaphylaxis. The post-test will involve the identical questions and enquire regarding the usefulness of the training in future medical practice and if the experience lessened the burdens of the previously encountered barriers. Detailed comparative data will be reviewed by the stakeholders. Data from the tests will be analyzed for statistical significance.

Optimizing Safety: Role of the Clinical Pharmacist

Given the heterogeneity of the formulations of epinephrine and intricacies in its dosing, it is the suggested that a Clinical Pharmacist be participating in the deployment of the curriculum. Epinephrine/EAI use is the mainstay treatment in Anaphylaxis.[48] As a nonselective alpha- and beta-adrenergic receptor agonist, it causes vasoconstriction, increased blood pressure, mast cell stabilization, increased vascular permeability (via α agonism), increased heart rate and contraction, smooth muscle relaxation in the lungs, stomach, intestine, uterus, and bladder (via β agonism).[49] Consequently, the dyspnea, bronchospasms, angioedema, urticaria et al seen in anaphylaxis is powerfully diminished by epinephrine use, highlighting its fundamental role in the treatment of this HALO event. As previously stated, improper or delayed administration of epinephrine is a patient safety concern, as anaphylactic symptoms progress rapidly and exponentially.[50] Remarkably, no absolute contraindications exist for the administration of epinephrine in treating anaphylaxis.[51] Side effects such as anxiety, tremor, and tachycardia mimic the innate epinephrine release in sympathetic nervous system

activation. Adding to the confusion, EAIs routinely come in three formulations: 0.1 mg Auvi-q, 0.15 mg EpiPen Jr, and 0.3 mg EpiPen, or as a 1mg/1mL (1:1000) or 0.1mg/mL (1:10,000) solution.

Unfortunately, despite its clear vitalness in the treatment of anaphylaxis, dosing errors in epinephrine administration have resulted in death.[52,53] Such errors highlight the difficulty and disparity in understanding epinephrine concentrations among trainees, and the absolute criticality in educating said providers accordingly.

Conclusions

SBE methodologies are ideally suited for HALO experiences. HALO experiences such as Anaphylaxis, by their nature, require educational strategies that involve experiential learning. Embedding curated Educational Theories enhance learning. Anaphylaxis training across disciplines is not optimal and is a patient safety concern. Leveraging educational theories in a rich manikin-based technology environment, and an engaged adaptive learner-driven curriculum ameliorates the learning experience. Institutional training for HALO events is not optimized and Simulation-Based Educational methodologies are preferred to lecture-based curricula. It is anticipated that the authors will implement this curriculum at their institution in the near future. Other institutions may deploy and implement it as suited to their own curricular needs. Active learning enhances engagement in SBE, thus leading to better outcomes. A rigorous and structured post-encounter facilitated debrief session is essential to close the learning gap. Debriefing is more than enunciating "good job". Pre- and post-session evaluations assess multi-faceted competency outcomes and thus discern domain deficiencies. Assuaging the CL further ameliorates the learning experience.

Disclosure

The authors report no conflicts of interest in this work.

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