Abstract

Introduction: Critical events are frequently managed by individuals with different skill sets, funds of knowledge, and experiences who form ad hoc teams on a daily basis without any previous practice together. Such groups’ spontaneity of formation puts a premium on individuals’ ability to understand team cognition and work together. Team cognition can be thought of as an analogue of individual cognition and is revealed during functional interactions of team members working interdependently on a shared goal. This simulation helps trainees develop and practice team-training skills in order to better form ad hoc teams and manage critical events. Methods: This simulation can be applied to senior medical students and residents and focuses on the management of an accidental administration of potassium leading to hyperkalemic arrest. The simulation takes 10 minutes to complete and, when coupled with a debriefing session, can be accomplished in under 45 minutes. Results: Twenty-two trainees, consisting of five teams of four to five residents, participated in this simulation. Each team showed varying levels of team cognition, and most successfully managed the hyperkalemic arrest; both of these points were reviewed at length during the debriefing. The trainees gave the simulation high ratings in terms of its effectiveness for team training, with a score of 6.7 on a scale of 1-7. Discussion: Medical simulations have been very productive in providing learners with opportunities to manage critical events. With the exploding practice of interdisciplinary medicine, we believe simulation-based training should be implemented to develop team cognition and practice team training.

Keywords
Simulation, Team Training, Team Cognition, Hyperkalemic Arrest, Ad Hoc Teams

Educational Objectives
By the end of this session, learners will be able to:
1. Develop and practice knowledge, skills, and attitudes relating to team cognition.
2. Manage pulseless electrical activity.
3. Identify pulseless electrical activity on examination.
4. Initiate advanced cardiac life support.
5. Recognize the hyperkalemic etiology.
6. Manage the second victim phenomenon.

Introduction
Health care delivery systems that focus on a team-centric philosophy have become the foundation for patient care models throughout the country. This team-centered approach extends from the outpatient clinic setting to the high-acuity intensive care arena. Along those lines, health care has also become interprofessional, with individuals of various skill sets, knowledge bases, and levels of experiences all working together to accomplish a shared goal. Subsequently, this task interdependency, with each member possessing unique abilities and knowledge, mandates that the team members work together if they wish to succeed. This interdependency has exposed a gap in most health care training: team cognition.

Team training has been demonstrated to improve clinical performance, organizational outcomes, and
most importantly, patient outcomes. Team training focuses on developing and practicing the knowledge, skills, and attitudes (KSAs) needed to accomplish shared goals. These KSAs have been elucidated by Ed Salas in his development of Team Strategies and Tools to Enhance Performance and Patient Safety (TeamSTEPPS), a system designed to improve team performance in health care delivery. Three of the faculty involved in developing the current simulation are TeamSTEPPS Master Trainers and are very comfortable teasing out the impact of KSAs in clinical practice. By implementing facsimiles of various clinical scenarios, simulation-based training (SBT) allows learners to develop the knowledge and skills to effectively manage similar real-world events. SBT has been shown to improve technical skills and behavioral learning outcomes and has beneficial impact on patient-related outcomes. By enveloping the fundamental KSAs of team-based training in SBT, educators are able to simultaneously develop team cognition along with the diagnosing and management of illnesses.

In this simulation, a group of first-year residents forms a first-response team to answer the call of a nurse in distress as a result of a patient's decompensation. Prior to entry, each team member is unknowingly presented with unique information about the scenario that could facilitate an expeditious diagnosis and recovery. Upon arrival at the unit bed, the team is confronted with numerous sources of information, a decompensating patient, and a very distressed nurse. The residents are challenged to come to together as an ad hoc team, work through the various pieces of information, handle the distressed nurse, and manage the critically ill patient in a short period of time. In this module, we present the details of the simulation, including all of the supporting material, the framework for the debriefing, and additional sources of information.

MedEdPORTAL has appreciated the importance of team training, as evidenced in some of its publications that can help develop these team skills in learners. Specifically, publications by Atallah, Kaplan, Ander, and Robertson; Sawyer, Laubach, Yamamura, Hudak, and Pocrnich; and Wong, Gang, Wing, Ng, Szyl, and Mahoney address some of the KSAs that interprofessionals use to develop better team cognition and similarly highlight TeamSTEPPS fundamentals echoed in this module. This module builds on that vernacular and ideology by specifically focusing on a few of the KSAs that can be honed during a critical event. By coupling these team-training skills with ad hoc team formation and high-fidelity simulation, this module highlights many of the tools and challenges that MedEdPORTAL acknowledges in other publications by Higgins Joyce; Forest, Lie, and Ma; Lu, Goolsarran, Hamo, Frawley, Rowe, and Lane; and Heath, Kohn, Sargsyan, et al. We believe this module is a useful addition to the journal.

**Methods**

At our institution, we implemented this team-training exercise with two different audiences: fourth-year medical students and interns. We obtained IRB approval for this team-training exercise to evaluate its educational impact on the participating residents. Initially, the simulation targeted 22 first-year residents, which is what our evaluation data represent. Subsequently, we expanded the simulation to over 100 fourth-year medical students. The simulation (Appendix A) required one instructor who functioned as the nursing confederate and a technician to run the simulator, although these can be the same person if personnel are limited.

The module includes several files with additional information to move the simulation along: an instructor details document (Appendix B), a team cognition details document (Appendix C), and a hyperkalemic arrest details document (Appendix D). Also included are a critical action checklist (Appendix E), a patient history and physical document (Appendix F), and a patient lab values document (Appendix G).

**Equipment/Environment**

The patient was replaced by a Laerdal SimMan 3G, which was able to reveal vital signs (pulse oximetry, electrocardiogram tracing, and noninvasive blood pressure cuff). The mannequin, dressed in a hospital gown, was attached to four infusions: a potassium chloride 40mEq bag, 1 liter of normal saline, a bag of Ciprofloxacin 200mg antibiotic, and a bag of Flagyl 500mg antibiotic. A patient chart with history and
physical was available to read at the foot of the bed. A code cart with advanced cardiac life support (ACLS) medications and a defibrillator were in the room. An ACLS protocol binder was present, and the opening page inside the binder detailed pulseless electrical activity (PEA) management, depicting the five Hs and Ts. Airway equipment was present: Macintosh 3 blade, Miller 2 blade, endotracheal tube 7.0, 7.5, 8.0, and stylets, bag-valve mask, and oxygen source (optional). A suction canister was available (optional). Four pieces of paper explained the team hospital role, as well as the message from the calling nurse; each informational blurb had a unique piece of information embedded in the paragraph (Appendix H). Arterial blood gas paper reading was available upon request (this delayed the results by 2 minutes). Infection control gowns were available at the room’s entryway.

Personnel
Each team comprised four to five members who could be interns from any medical or surgical discipline or fourth-year medical students. At our institution, the simulation was run with interns from the Department of Anesthesiology.

The nurse in our scenario was a faculty member wearing a badge that read Nurse, although this person need not be a faculty member. The nurse provided information if the team was struggling and impeded the team’s success by misdirection if the team was too expeditious.

The mannequin could be programmed to deteriorate into PEA over time or when triggered by another person (including the nurse if personnel are limited). The arrest was overcome by administration of calcium chloride, which was the only intervention that could change the course and thus would need to be addressed.

Assessment
In this SBT case, we had four to five first-year residents randomly form a team responsible for responding to hospital-wide emergencies. To reflect the reality that each team member possesses unique skills, experience, and knowledge, the team members received and read a brief synopsis of the phone call before entering the room. Each of these pieces of information appeared identical; however, each member’s synopsis contained different embedded pieces of information that, if shared, could facilitate a speedy patient recovery. This wrinkle was added not only to demonstrate that each individual brings something unique to the team but also to show how high-functioning teams share unique information.\(^\text{12}\)

Upon entering the room, the team was confronted with a nurse who was exceptionally distressed by the situation. The details of the instructor actions and possible courses of action to help facilitate the simulation flow can be found in the instructor case details (Appendix B). The patient had a very complex history, as well as a hospital course that challenged the capabilities of the nurse. This complexity was exacerbated by multiple changing interventions and needs, as well as a decompensating patient. The nurse acted very overwhelmed and uncertain, and this behavior deteriorated as the patient became hemodynamically unstable and went into PEA. Eventually, the team discovered that the nurse had inadvertently bolused the potassium chloride instead of the crystalloid, which precipitated the PEA arrest. The nurse decompensated as he/she experienced the second victim phenomenon,\(^\text{13}\) and this decompensation also challenged the team.

Along with managing the nurse, the team needed to work through multiple sources of information available in the room. The team had a patient chart, multiple intravenous infusions running, the presentation of the patient, a bedside emergency manual, and the unique pieces of information discussed earlier. Once the team encountered the patient, the patient would transition from groaning but stable to hemodynamically unstable to PEA in approximately 3 minutes.

The primary objective of this SBT exercise was to achieve the four KSAs (Appendix I) considered to be focal points to navigating the scenario: leadership, shared mental model, mutual performance monitoring, and closed-loop communication. With time being very limited and the acuity being very high, we believe
that in order to quickly and effectively manage this event, the team needed to prioritize these skills in particular, although we would not dismiss the importance of all of the KSAs. Leadership is a common skill for effectively managing a critical event.\textsuperscript{14} We expected that prior to entering the room (or any critical event), the team should designate a leader who would be responsible for directing and coordinating the other members, as well as assessing team performance.\textsuperscript{15,16} The quicker a team could develop and maintain a mutually appreciated understanding of the event, the more efficient and successful the team would be. Furthermore, this shared mental model can help team members anticipate the team’s needs, as well as identify changes in the team, task, or situation.\textsuperscript{17} Team members must practice closed-loop communication if they expect their requests and needs to be reliably addressed. Closed-loop communication is the initiation of a message by a sender, the receipt and acknowledgment of the message by the receiver, and, finally, the verification of the message by the initial sender. All too frequently, requests are made or tasks announced during a crisis that are not fulfilled or appreciated.\textsuperscript{18} The last of the KSAs we focused on in this SBT was mutual performance monitoring, which mandates that teams should be capable of appreciating the demands of their surroundings and use strategies to monitor each team member’s performance.

The secondary objectives of this exercise were the institution of ACLS in the face of a hyperkalemic arrest and management of the second victim phenomenon. Recognizing the etiologies of PEA can be daunting under stressful and uncertain events, and SBT can be an effective strategy in building the competencies and skills needed to treat these events. If the team is unable to determine the differential diagnosis from its own knowledge base, it should find and utilize the ACLS protocol binder on the code cart. The second victim phenomenon is a well-known occurrence in medicine that has been shown to significantly impact individual, as well as team, functioning. Understanding this victimhood and knowing how to address it are very important keys to health care worker well-being.

Debriefing

Although not necessary, our facility video-recorded these simulations in order to show the team how it performed as part of the debriefing. The facilitator was tuned into the opportunities for the team to demonstrate four key KSAs: leadership, shared mental model, mutual performance monitoring, and closed-loop communication. Immediately, team members were asked what their reactions were, what they thought about the experience, and how they thought they had performed.\textsuperscript{19} After the initial emotions were expressed and these follow-up questions were discussed, the facilitator asked more detailed questions pertaining to the KSAs witnessed or not witnessed in order to address and close any performance gaps.\textsuperscript{11} The focus of this debriefing should stay on the team-training aspects of diagnosis and interventions in the scenario. ACLS interventions, timeliness, understanding, and success are important, but the focus should be on the facility of the team to accomplish them collectively using the specific KSAs. A debriefing foci document (Appendix J) is included to assist facilitators. The simulation critical action list (Appendix E) can also be used as an observer evaluator tool for residents or students observing the simulation, which can elicit greater group participation. During the debriefing, this critical action list can be referenced and discussed for further support of behaviors.

Results

To evaluate the implementation process of this simulation-based team-training exercise, we initially test-ran three groups of critical care fellows, which was very useful in working out the kinks. A key tool in this simulation is the activity level of the instructor who is playing the nurse. Teams of varying skill emerge, and subsequently, their ability to diagnose and treat the critical patient varies tremendously. In order to compensate for this variability, the instructor often needs to either speed up or slow down the team’s appreciation and interventions. Some of these opportunities can be found in the team cognition details (Appendix C).

Initially, 22 first-year residents participated in this simulation. These initial exercises provided our
quantitative data. Subsequently, we have had over 100 fourth-year medical students participate in the exercise. Interestingly, despite the difference in educational or clinical experience, the fourth-year medical students often outperformed the interns. This finding was captured only on a subjective overall appraisal of the experience by the faculty who took part and thus was not quantifiable. Regardless, we propose that this finding could demonstrate that team behaviors are not acquired through time or on-the-job training but instead need to be developed and practiced.

Each cohort of participants from the 22 first-year residents evaluated the simulation following the debriefing. They overwhelmingly enjoyed the simulation-based team-training exercise and asked to continue the theme in future drills. The quantitative data revealed an overall 6.7 on a scale of 1 to 7 (7 = best). The material was considered clear (6.4), the objectives were achievable (6.4) and applicable (6.4), and the exercises stimulated future learning (6.6). The qualitative feedback was universally positive. Comments included the following:

- “I didn’t know much about teamwork theory.”
- “Well-organized and fun.”
- “It made me think how to improve team dynamics.”
- “Quality information that I will use to improve teamwork.”

Discussion

SBT exercises provide a venue to teach and learn the essential KSAs that individuals can execute within ad hoc teams to manage various crises. A variety of themes in simulations can provide an opportunity to expose the need for this type of training, and we chose an iatrogenic injury resulting in PEA arrest. Key to this simulation design was creating a medically based, real-world scenario to captivate new learners’ attention and subtly introduce the demand for team behaviors. We attempted to weave the need for team cognition into this exercise in three ways: providing multiple sources of information, limiting the available time by expediting the hyperkalemic arrest, and forming an ad hoc team that had not worked together before. These KSAs are obviously not unique to this specific simulation; they form the infrastructure for any highly functioning team. The four KSAs focused on here are not the only ones applicable to this simulation; in fact, all can be appreciated. However, we specifically designed this simulation to promote their individual impact and importance. By designing SBT exercises to focus on these generalizable team KSAs, participants can transfer the practiced skills to their daily work environment as they work among different teams on a daily basis. Furthermore, simulations with appropriately directed debriefing allow learners to experience the stress and rapid pace of acute health care crises, which translate into high-quality experiential learning that learners enjoy. Our participants appreciated the focus on team training, which was a completely unique experience for all of them.

For every critical event, a leader should emerge who can recognize the multiple sources of information presented to the team and distribute the workload appropriately. We did not assign a leader or ask the teams to choose one, and this became readily apparent during our debriefings. Our simulations revealed opportunities for a leader to intervene and ask for assistance with tasks that were not being accomplished sufficiently. Managing the distressed nurse and providing ACLS for PEA were the most frequent examples in our simulations.

As mentioned earlier, quickly developing a shared appreciation or understanding of an event can significantly alter the interventions made and, thus, their success. Unfortunately, this requires humility because each member must be willing to audibly work through many uncertainties and misperceptions to effectively share his or her perspective. This degree of vulnerability and self-effacement puts a premium on trust and respect within the team. Along these lines, high-performing teams willingly share unique information that is often linked to their professional expertise: surgical, critical care, pharmaceutical, nursing, medicinal, and so on. Most team members have few problems sharing commonly understood
information but are often less willing to reveal unique information, which they believe the team either may not be interested in or may already appreciate. This simulation attempted to artificially demonstrate the importance of this willingness to share unique information by giving each participant snippets of information that appeared common (or shared) but were actually unique and germane to the patient’s care. None of the participants identified that each piece of information was unique and thus worthy of discussing with the team during the simulation.

In order to effectively make interventions and improve care, teams must practice closed-loop communication. Our participants commented that closed-loop communication often felt excessive or redundant, which was why they omitted it during events. That said, the vast majority of them believed it to be a critical component for high-performing teams. The SBT provided multiple opportunities to demonstrate or fail to demonstrate this skill: ACLS management, history and physical review, and lab or test orders. We found that video playback was an outstanding tool to expose the value of closed-loop communication or lack thereof, which resonated loudly with the participants.

The last of the KSAs that we focused on in this exercise was mutual performance monitoring. Fault-tolerant systems require that team members are able to identify mistakes and lapses in other team members’ actions, as well as provide feedback to facilitate self-correction. Some frequent examples that demonstrated this need during the simulations were the adequacy of chest compression depth, minute ventilation, and ACLS protocol deviation or implementation. In this SBT case, the lack of addressing or handling the distressed nurse was the most frequent performance that was not monitored or managed well: Most participants commented that they were unsure how to handle the situation.

A few ideas emerging over the last year have allowed us to improve this experience for everyone. Although not necessary, we found that by video-recording and then immediately reviewing the simulation as a group, the participants were better able to address faults and opportunities. This most likely stemmed from the fact that people often remember things very differently from one another: lengths of time, physical gestures, and communication lines, among other things. With the ubiquity of smartphones and their high fidelity, this should be less of an obstacle to capitalize on. Next, we have decided to provide the checklist to those students or residents who do not take part in the simulation. This allows them to appreciate the underlying but primary goal of the simulation: team cognition. By observing the simulation through this lens, we feel that they effectively become active participants and that they can also assist us in the debriefing process with objective data. We initially had some minor concerns that this peer-to-peer assessment could be interpreted as judgmental or threatening, but we have found the exact opposite to be true. The majority of evaluating observers were more complimentary on the high points and empathetic on the low points. Simultaneously, the participants welcomed the feedback from their evaluating peers and frequently elicited more. Coincidentally, students found that these checklist assessments bolstered the mutual performance monitoring skill that we were developing during the simulation. We have also included multiple appendices to help specify opportunities to tailor this simulation to any institution’s needs: instructor details, lab details, patient history and physical options, team-training checklists, and debriefing foci. While some of these appendices may at first seem unnecessary, they allow other institutions to exactly replicate a product that has been very successful at our institution. By developing numerous SBT exercises that focus on reoccurring hospital emergencies, we believe that we can eventually cover all of the KSAs requisite for high-functioning teams. We have learned that a maximum of four KSAs should be included per simulation and that including only two to three increases a lesson’s impact and effectiveness.

Our implementation of specific and individualized snippets of information may not equate to unique skill sets or clinical acumen. Thus, it would not be fair to assume that since the participants did not share this information, they would not share their appreciation of the event, which would limit its applicability. However, we believe this wrinkle allows for a richer discussion during the debriefing about the importance of sharing unique information, as opposed to common knowledge. Another limitation we found was that
when evaluating sociological phenomena embedded in the KSAs of team cognition, participants needed a strong willingness to suspend disbelief. Frequently, participants commented that they did not correct their team because they figured the skill was being demonstrated, albeit inadequately. This made mutual performance monitoring and some components of leadership more difficult to assess.

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References
1. Schmutz J, Manser T. Do team processes really have an effect on clinical performance? A systematic literature review. Br J Anaesth. 2013;110(4):529-544. https://doi.org/10.1093/bja/aes513
2. Neily J, Mills PD, Young-Xu Y, et al. Association between implementation of a medical team training program and surgical mortality. JAMA. 2010;304(15):1693-1700. https://doi.org/10.1001/jama.2010.1506
3. TeamSTEPPS. Agency for Healthcare Research and Quality website. https://www.ahrq.gov/teamstepps/index.html. Accessed March 6, 2017.
4. Cook DA, Hatala R, Brydges R, et al. Technology-enhanced simulation for health professions education: a systematic review and meta-analysis. JAMA. 2011;306(6):978-988. https://doi.org/10.1001/jama.2011.1234
5. Atallah H, Kaplan B, Ander D, Robertson B. Interprofessional team training scenario. MedEdPORTAL Publications. 2009;5:1713. http://doi.org/10.15766/medeportal.2009.5.1713
6. Sawyer T, Laubach V, Yamamura K, Hudak J, Pocnich A. Interprofessional teamwork training in neonatal resuscitation using TeamSTEPPS and event-based approach simulation. MedEdPORTAL Publications. 2013;9:9583. http://doi.org/10.15766/medeportal.2013.9.9583
7. Wong A, Gang M, Wing L, Ng S, Szyld D, Mahoney H. Team training for success: an interprofessional curriculum for the resuscitation of emergency and critical patients. MedEdPORTAL. 2014;10:9807. http://doi.org/10.15766/medeportal.2014.10.9807
8. Higgins Joyce A. Team-based simulation for medical student handoff education. MedEdPORTAL. 2016;12:10486. https://doi.org/10.15766/medeportal.2016.12.10486
9. Forest CP, Lie DA, Ma SB. Evaluating interprofessional team performance: a faculty rater tool. MedEdPORTAL. 2016;12:10447. http://doi.org/10.15766/medeportal.2016.12.10447
10. Lu W-H, Goolarann N, Hamo CE, Frawley SM, Rowe C, Lane S. Teaching patient safety using an interprofessional team-based learning simulation model in residency training. MedEdPORTAL. 2016;12:10409. http://doi.org/10.15766/medeportal.2016.12.10409
11. Heath J, Kohn R, Sargsyan Z, et al. Simulation curriculum in internal medicine: decision-making training for interns focusing on acute clinical scenarios in critical care. MedEdPORTAL. 2015;11:10061. http://doi.org/10.15766/medeportal.2015.11.10061
12. Mesmer-Magnus JR, DeChurch LA. Information sharing and team performance: a meta-analysis. J Appl Psychol. 2009;94(5):535-546. http://dx.doi.org/10.1037/a0013773
13. Quillivan RR, Burlison JD, Brown EK, Scott SD, Hoffman JM. Patient safety culture and the second victim phenomenon: connecting culture to staff distress in nurses. Jt Comm J Qual Patient Saf. 2016;42(8):377-386. https://doi.org/10.1016/j.jqps.2016.06.009
14. Cannon-Bowers JA, Tannenbaum SI, Salas E, Volpe CE. Defining competencies and establishing team training requirements. In: Guzzo RA, Salas E, eds.Team Effectiveness and Decision-Making in Organizations. San Francisco, CA: Pfeiffer; 1995:333-380.
15. Barach P, Weinger MB. Trauma team performance. In: Wilson WC, Grande CM, Hoyt DB, eds. *Trauma: Resuscitation, Anesthesia, Surgery, and Critical Care*. Vol 1. New York, NY: CRC Press; 2007:96-150.

16. Healey AN, Undre S, Vincent CA. Developing observational measures of performance in surgical teams. *Qual Saf Health Care*. 2004;13(suppl 1):i33-i40. https://doi.org/10.1136/qshc.2004.009936

17. Mathieu JE, Heffner TS, Goodwin GF, Salas E, Cannon-Bowers JA. The influence of shared mental models on team process and performance. *J Appl Psychol*. 2000;85(2):273-283. https://doi.org/10.1037/0021-9010.85.2.273

18. McIntyre MR, Salas E. Measuring and managing for team performance: emerging principles from complex environments. In: Guzzo RA, Salas E, eds. *Team Effectiveness and Decision-Making in Organizations*. San Francisco, CA: Pfeiffer; 1995:194-203.

19. Rudolph JW, Simon R, Raemer DB, Eppich WJ. Debriefing as formative assessment: closing performance gaps in medical education. *Acad Emerg Med*. 2008;15(11):1010-1016. https://doi.org/10.1111/j.1553-2712.2008.00248.x