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Use of a High-Fidelity Patient Simulator to Introduce an Evidence-Based Emergency Manual into Certified Registered Nurse Anesthetist Practice

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Abstract

Certified Registered Nurse Anesthetists (CRNAs) administer anesthesia care to thousands of patients each year. Despite increased anesthetic safety, low-frequency, high-risk perioperative critical events still occur. Although CRNAs have been expected to rely on memory alone to manage the spectrum of these critical events, the use of an emergency manual (EM) may improve CRNA performance. Recent experiences with similar critical events at one Army community hospital led to the development of the following question: Will the use of high-fidelity simulation training with the CRNAs on the use of EMs produce both increased performance in key tasks and positive satisfaction scores related to the use of the emergency manual during critical events now and in the future? Twenty CRNAs participated in high-fidelity simulated scenarios involving low-frequency, high-risk critical events before and after training on the use of an EM based on a change strategy developed by Goldhaber-Fiebert and Howard in 2012. Changes in performance after training were evaluated using a tool designed by Arriaga et al. Before EM training, CRNAs completed 46.05% of key tasks in the simulated scenario. After EM training, CRNAs completed up to 94.02% of key tasks in simulated scenarios. The increased completion of key tasks by CRNAs during simulated critical events after EM training and increased satisfaction scores. These results demonstrate how a well-constructed training program facilitates implementation of an evidence-based EM into practice.

INTRODUCTION

Certified Registered Nurse Anesthetists (CRNAs) provide anesthesia for thousands of patients annually. Despite their qualifications and skills, which have drastically reduced the morbidity and mortality of patients under anesthesia, low-frequency, high-risk perioperative critical events still occur, including sudden cardiac arrhythmia, airway fire, anaphylaxis, hemorrhage, local anesthetic toxicity, and embolism.[1] The overall incidence of perioperative critical events has been estimated at 145 events per year for a hospital that performs 10,000 operations.[2,3] Thus, critical events may be so rare that individual anesthesia providers never experience them in practice, preventing opportunities to form pattern recognition, which is a key characteristic of expert clinical decision-making.[4] CRNAs are expected to rely on memory alone to recall key actions and seamlessly manage a wide array of critical events, therefore, mismanagement or deviation from accepted practice due to human error, may account for a substantive portion of anesthesia-related risk.[5] Utilization of an emergency manual (EM) can increase the number of key actions completed by anesthesia providers during low-frequency, high-risk perioperative critical events.[6-10]

In 1924, Babcock expressed if a critical event during surgery required a response that was not instantly obtained by simple measures, a fixed emergency routine should be posted on the walls of every operating room, drilled into every staff member, and strictly enforced.[11] Over 90 years later, there remains a cultural reluctance among anesthesia providers towards use of emergency checklists during perioperative critical events, with one study reporting 60% of anesthesia residents believing they should be able to manage a critical event from memory alone.[6] Substantial evidence indicates anesthesia providers routinely do not remember all actions involved in managing emergent events from memory alone.[12] Indeed, three recent editorials make the same plea as Babcock did in 1924, concluding it is time to adopt the use of emergency routines during the perioperative period.[11] Several studies demonstrate healthcare providers perform poorly when relying solely on memory to manage simulated critical events.[8,13-16] For instance, Smith et al found a rapid decline in Advanced Cardiac Life Support (ACLS) skills among nurses after 3 and 12 months post-training, (30% and 14% of nurses, respectively).[13] Similarly, 6 months after advanced life support training, Semeraro et al found a 36% reduction in the number of anesthesiologists who passed a multiple-choice test, a 1-min increased time to first defibrillation, and other delayed or forgotten interventions.[14] Berkenstadt et al reported a decay in knowledge and skills during simulated cardiac arrest in obstetric patients, with only 0–4% of anesthesia providers removing fetal monitors, 44–68% positioning the patient with left uterine displacement, 48–78% maintaining cricoid pressure during ventilation, and 40–83% delivering the fetus by caesarean in 5 min or less.[15] Henrichs et al found that although anesthesiologists performed better than CRNAs in eight simulated perioperative critical events, both groups performed poorly overall, completing only 66.6% and 59.9% of key tasks, respectively.[16] In a simulated malignant hyperthermia scenario, Harrison et al found that not all teams needed a cognitive aid to perform well. However, the teams that performed well often used an aid, whereas the teams that performed the most poorly did not use an aid.[8] It may be impossible to prospectively determine whether a team will perform well in a crisis situation but may be prudent to train all teams on the use of cognitive aids and ensure aids are readily available during unfamiliar or life-threatening situations.

PICOT QUESTION & MODEL

The target institution for this project performed approximately 10,000 operations per year. In 2014-2015, there were several incidents of low-frequency, high-risk, critical events that challenged anesthesia providers to make accurate, evidence-based decisions while under a high level of stress and during hours when additional staff may not be available. As a countermeasure to these situations, our team developed the following PICOT question: Would the use of high-fidelity simulation training using EMs conducted over one week with practicing CRNAs produce both increased performance in key tasks and positive satisfaction scores related to the use of the emergency manual during critical events now and in the future?

The change strategy adopted for this project developed by Goldhaber-Fiebert and Howard called for a four-step process to achieve success within an institution when implementing an EM.[17] The first step was to create or adapt an EM on the local level to meet the specific needs of the institution. Second, training was incorporated to increase CRNA familiarity with the EM. Third, it was ensured that the EM was accessible and effectively used. Finally, integrating the EM was integrated as a part of the institution's quality and safety culture. Utilizing this strategy and adapting it to the specific constraints of our facility, our team sustained a change in practice among our anesthesia providers and better outcomes for our patients when faced with critical events.

TRAINING PROGRAM

After receiving exempt status from the Institutional Review Board, the project was conducted at an Army community hospital over a 5-day period in April 2017. Data collection and training were carried out in a manner similar to that described by Goldhaber-Fiebert et al.[9] Twenty CRNAs were divided into teams of two, and pre-training data collection, training, and post-training data collection and subjective evaluation were completed within a 150-min session. For pre-training data collection, the number of key tasks completed by groups were counted during a high-fidelity simulation of a perioperative critical event (eg, anaphylaxis). CRNAs were then trained on the use of the selected EM through a trigger film on severe bradycardia. The EM chosen for this project was the Stanford Emergency Manual version 3.1 that included validated algorithms for twenty-five different perioperative emergencies and anesthesia crisis resource management (ACRM) resources.[18] For post-training data collection, CRNAs used the EM during two additional simulations of perioperative critical events (eg, intraoperative hemorrhage and ventricular fibrillation/cardiac arrest), and the numbers of key tasks completed were counted. For each simulation, one CRNA served as the primary provider or "leader", and the other served as the emergency consult or "reader". The simulations were conducted as described by Arriaga et al and video-recorded for data collection purposes.[19]

The simulated critical events were conducted using the Human Patient Simulator (HPS) with optional HPS equipment (CAE Healthcare). The HPS is the only human patient simulator that supported the modeling of potent inhalational anesthetics and exchanges oxygen and carbon dioxide gases to replicate patient physiology,[20] and it also integrated with clinical monitoring equipment. The HPS allows CRNAs to administer medications, indicated or contraindicated, during the scenario, with a subsequent automatic natural physiologic response. In essence, the HPS replicates human physiology in a response manner analogous to real patients enhancing the fidelity of the simulation experience.

The effectiveness of the training was assessed by tallying the proportion of key tasks completed during the post-training scenarios. Each simulated critical event was evaluated by two project team members who observed the scenarios in real time. In cases of discrepancy between team members, the video recording was used to confirm the observations. CRNAs' perceptions of the usefulness and clinical relevance of the EM were assessed using a questionnaire immediately after completing the first (eg, pre-training) and third (eg, post-training) scenarios to evaluate likelihood of adopting the EM in future practice. CRNAs were additionally surveyed to assess opinions on the quality of the overall session, EM checklists, and scenarios.

TRAINING RESULTS

Twenty CRNAs participated in the three high-fidelity simulated critical events; one scenario was delivered before EM training, and two scenarios were delivered after EM training. In the first scenario (anaphylaxis), CRNAs completed 46.05% of key tasks on average without EM use (Figure 1). The most common missed actions included failing to call for the code cart, continuing a volatile agent, not considering additional intravenous access, not administering a histamine-2 receptor antagonist, and not performing five additional actions related to post-anaphylaxis care and referrals.

In the second scenario (hemorrhage), CRNAs completed 80.56% of key tasks on average while using the EM. The most common missed actions included failing to call for the code cart, not placing the patient in Trendelenburg position, not confirming or placing a Foley catheter, and failing to call for the cell saver system. In the third scenario (ventricular fibrillation), CRNAs completed 94.02% of key tasks on average while using the EM. No major key actions were missed, with the exception of one instance of failing to consider antiarrhythmic medications. Administration of magnesium sulfate for Torsade de Pointes, and concurrent administration of calcium chloride, insulin, glucose, and sodium bicarbonate for hyperkalemia, were omitted as key actions because this scenario did not include either condition as a potential cause of ventricular fibrillation.

A questionnaire was provided to participating CRNAs after the first pre-training and third post-training scenarios (Table 1). The greatest change in score was for CRNAs' perception that they learned something new (+0.92) and feeling that they did things during the training day they never would have been able to practice otherwise (+0.64). The vast majority of CRNAs (98.8%) believed that EM use supported safer care and allowed them to be better prepared when confronted with anesthesia-related crises. CRNAs also believed that all operating room staff should be trained on EM use (97.8%), that the EM did not hinder clinical flow (97.8%), and that they would want the EM used if they were the patient (97.8%).

After the session, CRNAs were asked additional questions about the quality of the overall session, EM checklists, and scenarios; willingness to repeat the simulations and attend training again if it were provided off-site; feelings of overall stress while using the EM; and intention to use what was learned in future practice. CRNAs were also asked where in the operating room they felt would be most appropriate to place the EM after being fully implemented into local practice. CRNAs expressed satisfaction with the quality of the simulation, EM checklists, and scenarios. CRNAs also expressed an unwillingness to attend off-site trainings and general feelings of less stress when using the EM. The majority of CRNAs (71%) wanted the EM placed on the wall in the operating room in clear view using a document holder.

DISCUSSION

Consistent with the findings of Goldhaber-Fiebert et al and Arriaga et al, the authors observed EM training increased the proportion of key tasks completed during simulated critical events, from 46.05% after the first scenario to 94.04% after the final scenario.[9,10] This analysis was limited by the design of the training session and the small number of CRNAs completing the training. The large change in task completion rate led the authors to believe future implementation of the EM into CRNA practice at other facilities could yield significant improvements in response to low-frequency, high-risk perioperative critical events. Full implementation of EM training and practice among all anesthesia providers and operating room staff should be considered. It must be noted that the design of this project was intended to deliver the most complete training experience for the CRNAs by having them participate in all three clinical scenarios. Formal statistical analysis was not applied due to the lack of controls between scenarios or for repeated training effect. Regardless of these issues, the drastic change in key task performance proved invaluable when demonstrating the importance of using an EM for the management of critical anesthesia events.

Types of emergent high-fidelity simulation scenarios, selected for this project, produced some unexpected patterns of performance. The first scenario (anaphylaxis) yielded an appropriate acute response for all CRNAs involved (ie, call for help, increase FIO_2, epinephrine or albuterol administration), Overall rates of task completion ranged between 80–100%. Weaknesses in performance were observed in post-acute event care, including failure to administer histamine-2 antagonists and/or steroids, perform laboratory evaluation, consult the allergy service, and continue further observation, with completion rates ranging between 0–50%. Such weaknesses in post-acute event performance highlighted the need for CRNAs to use a cognitive aid, such as an EM.

The hemorrhage management noted deficiencies in four key tasks: calling for a code cart, placing the patient in Trendelenburg position, placing a Foley catheter, and calling for a cell saver system. The participants indicated they would have called for the code cart if the scenario had been perceived as leading to cardiac arrest as opposed to an isolated massive resuscitation effort. Trendelenburg positioning was frequently not considered in lieu of focusing on other key actions. In some cases, pre-placement of a Foley catheter was assumed due to the nature of the open abdominal surgery scenario, and cell saver capability was not available at the location where training was taking place. These shortfalls highlighted the need to tailor the scenarios and EM to increase relevance to the practice setting. More thorough briefing to address scenario key factors would have added clarity.

The ventricular fibrillation scenario demonstrated the highest levels of performance. No specific deficiencies were noted. Whether this improvement in performance across the three scenarios is the result of greater training effect within the simulation exercises and use of the EM, or experience and comfort in managing certain types of critical events, was difficult to ascertain within the scope of this project. However, this issue pointed toward potential areas for future research on training CRNAs to respond to critical events. Furthermore, it could have been possible that the highest rates of completion of key tasks in the ventricular fibrillation scenario were related to the frequency of training received on this event through ACLS recertification every two years.

CONCLUSION

Utilizing an EM during simulated critical events can increase the completion of key tasks by CRNAs, thereby enhancing the quality of care delivered to patients during perioperative critical events. Feedback shows positive trends that the training was perceived as both valuable and well-constructed. These findings are encouraging and justify expansion and inclusion of similar simulation-based EM training to include all disciplines of the perioperative healthcare team. Furthermore, widespread implementation of similar simulation-based training programs and ensuring the availability of EMs should be encouraged throughout all training and patient care arenas. The use of standardized EMs is relatively new within medical and nursing disciplines, and the best method of implementation is yet to be determined. However, with proper training, EMs have the potential to make a positive, enduring impact on care provided during low-frequency, high-risk critical events.[21]

SUMMARY OF KEY POINTS

- Cognitive aids in the form of emergency manuals have been shown to increase the performance of individuals and teams when faced with low-frequency, high-risk, critical events. Despite this evidence, culture within many medical disciplines still endorses working from memory alone.

- Some low-frequency, high risk, critical events are so rare that a provider may not encounter them throughout their career.

- Memory degrades over time and as such performance degrades as well. This is demonstrated by studies that have investigated the performance of practitioners in cardiac arrest management at after training. At six to nine months after training, most practitioners would fail a Basic Life Support or Advanced Cardiac Life Support test if taken without refreshments of knowledge and skills.

- The use of high-fidelity simulation provides a realistic platform for institutions to implement and sustain the use of an emergency manuals. Examination of the providers improved performance using the manual without patient risk can be convincing even to providers with the long-held belief that they need to remember everything.

- Emergency manuals when coupled with proper team dynamics such have the potential to greatly enhance patient outcomes to low-frequency, high-risk, perioperative critical events.

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Figure 1. Percentage of Key Tasks Completed During Simulated Critical Event Scenarios Before and After EM Training.

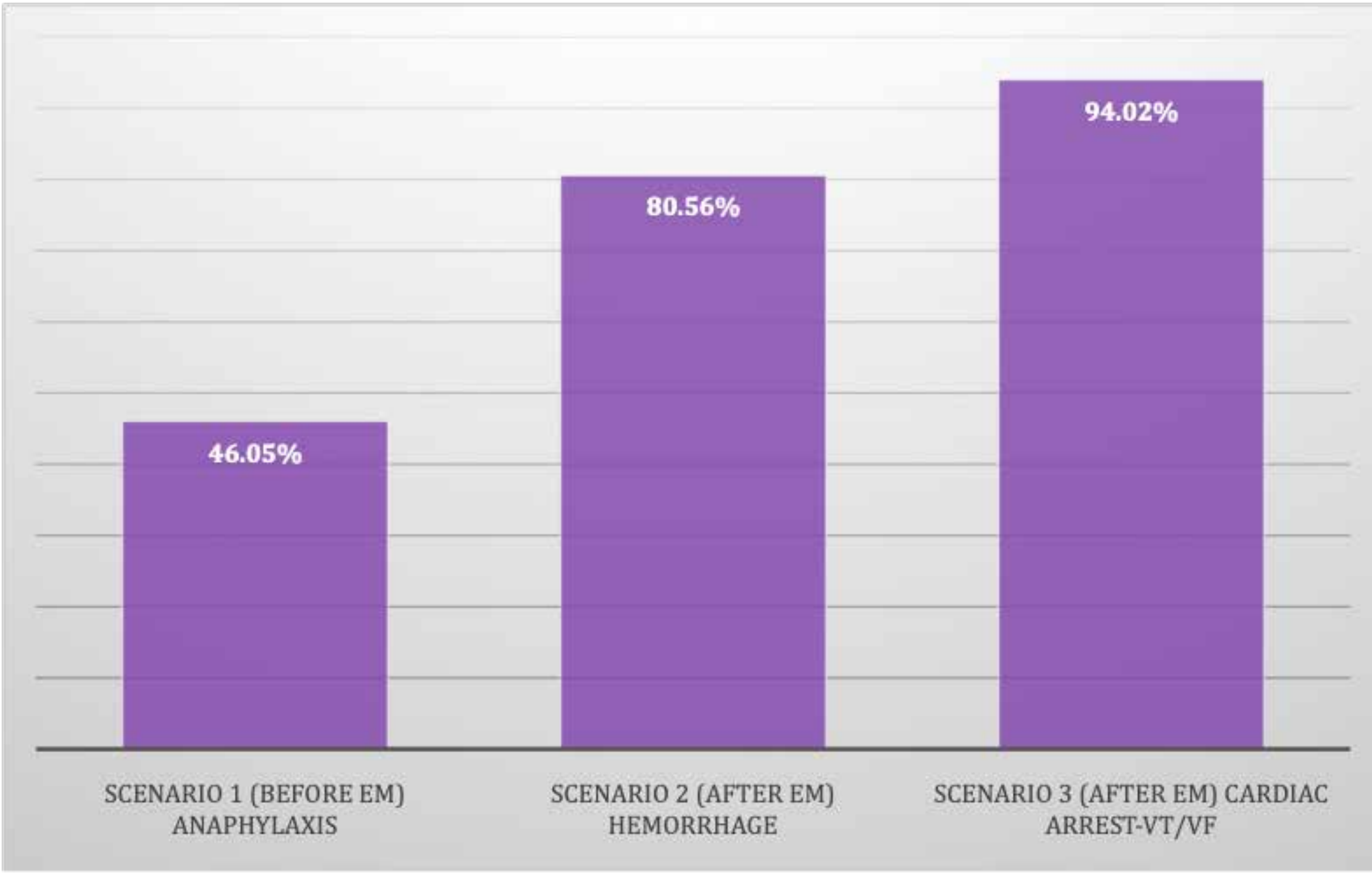

Table 1. CRNA Perceptions Before and After EM Training.

	Average Scores		
Question	**Before EM**	**After EM**	**Score Difference**
The scenario was realistic.	4.75	4.89	4.89
The scenario was appropriately challenging.	4.55	5.00	+0.45
This scenario will help me provide safer patient care.	4.65	4.94	+0.29
This scenario prompted realistic response from me.	4.58	4.83	+0.25
I felt I did things during this training day that I never would have had a chance to practice otherwise	3.80	4.44	+0.64
The knowledge gained will be helpful to me in my practice.	4.60	4.89	+0.29
I enjoyed the training session.	4.75	4.94	+0.19
I learned something new.	3.75	4.67	+0.92
This training session should be taken by all OR staff	4.50	4.89	+0.39

1=Strongly Disagree, 2=Slightly Disagree, 3=Neutral, 4=Slightly Agree, 5=Strongly Agree.

The questionnaire was adapted from that used by Arriaga et al.[19]