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Featured Article

High-Fidelity Simulation Training for Nurse Anesthetists Managing Malignant Hyperthermia: A Quality Improvement Project

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KEYWORDS
high-fidelity simulation;
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malignant hyperthermia;
quality improvement project;
nontechnical skills;
technical skills

Abstract

Background: Malignant hyperthermia (MH) is a low-frequency, high-impact event that many certified registered nurse anesthetists may be unprepared to manage due to limited clinical experience.

Method: A pretest, posttest, repeated-measures design was used to evaluate whether certified registered nurse anesthetists' MH knowledge improved immediately after and three months after high-fidelity simulation training. Technical and nontechnical skills were assessed during simulation training.

Results: After implementation, mean MH knowledge scores and self-confidence levels remained higher at three-month postimplementation than pretest scores.

Conclusion: MH simulation training increased participant's knowledge and self-confidence needed to manage an MH crisis.

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Malignant hyperthermia (MH) is a pharmacogenetic disorder of the skeletal muscles that presents as a hypermetabolic response when susceptible patients are exposed to triggering agents, such as volatile anesthetics and succinylcholine (Hirshey-Dirksen, Van Wicklin, Mashman, Neiderer, & Merritt, 2013). Although the genetic abnormalities responsible for MH are estimated to occur once in every 400 to 3,000 individuals, the prevalence of an MH crisis varies regionally from 1 in every 3,000 to 250,000 general anesthetics (Rosenberg, Pollock, Schiemann, Bulger, & Stowell, 2015). The exact number of annual MH crises is difficult to determine (Lu, Rosenberg, Brady, & Li, 2016).

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Although MH may present during or after anesthesia, it does not always occur with the first exposure (Rosenberg et al., 2015). Susceptible patients may have, on average, up to three uncomplicated anesthetics before experiencing an MH reaction (Rosenberg et al., 2015). This may mislead anesthesia providers to believe that it is safe for the patient to receive MH-triggering agents. Untreated MH can progress to a life-threatening condition with a mortality rate of 80% yet the mortality rate can be decreased to 5% with prompt recognition and appropriate treatment (Rosenberg et al., 2015). More recent episodes of MH may have a more insidious presentation that is harder to diagnose, as compared to the more common fulminant MH episodes of the past (Heytens, Forget, Scholtes, & Veyckemans, 2015). Subtle characteristics and presentations of MH may be due to advances in anesthetics and surgical practices such as less potent triggering agents of modern volatile anesthetics, less potent and long-lasting effects of some intravenous medications such as neuromuscular blocking agents, beta-adrenergic blockers, and alpha 2 adrenergic receptor agonists or quicker, less invasive medical techniques such as laparoscopic procedures (Heytens et al., 2015). Similarly, unusual presentations make it difficult for anesthesia providers to differentiate MH from other disorders that have similar clinical presentations (Hara, Hosoya, Deguchi, & Sawamura, 2016).

Key Points

- Malignant hyperthermia is a low-frequency, high-impact event that many certified registered nurse anesthetists may be unprepared to manage due to limited clinical experience.
- Simulation training can complement periodic educational sessions and episodic clinical experience to prepare anesthetists to manage an MH crisis in a timely and comprehensive manner.
- The use of high-fidelity simulation training for low-frequency, high-impact events has been shown to optimize clinical performance and to acquire the knowledge, nontechnical skills, and technical skills needed to manage an MH crisis.

Literature Review

Low-frequency, high-impact events such as an MH crisis can be challenging for anesthesia providers. In a quasi-experimental study by Henrichs et al. (2009), a simulation-based skills assessment of certified registered nurse anesthetists (CRNAs) and anesthesiologists demonstrated that anesthesia providers received an overall mean Key Action Checklist score of 44% out of 100% when diagnosing and initiating MH treatment. Despite years of clinical experience and vigilance, adverse events can still occur when providers are confronted with low-frequency, high-impact events (Hawkins et al., 2014; Wunder, 2016).

Crisis management requires not only knowledge and self-confidence but also technical and nontechnical skills (Wunder, 2016). Technical skills involve the ability to recall knowledge and accomplish key diagnostic and therapeutic actions during an event (Murray, Boulet, Kras, McAllister, & Cox, 2005). Various studies have shown that simulation increases technical skills, improves performance time, and increases recognition and reaction time (Orique & Phillips, 2018; Tan, Pena, Altree, & Maddern, 2014). Nontechnical skills include leadership, effective communication, situational awareness, and teamwork (Flin, Glavin, Patey, & Maran, 2012). Both technical and nontechnical skills are key for safe effective crisis management and positive patient outcomes (Wunder, 2016). When adverse events occur, they are more often due to a lack of nontechnical skills rather than technical skills (Wunder, 2016). Recent studies have shown that simulation has been successful in training team dynamics, technical and nontechnical skills, and that when taught together, technical skills increased through nontechnical skills training (Tan et al., 2014; Wunder, 2016).

Simulation enables providers to obtain valuable hands-on training without risking patient safety and is described as a positive training and education method under realistic conditions that plays an integral role in ensuring competency with essential clinical skills (Hirshey-Dirksen et al., 2013). Studies have shown that high-fidelity simulation (HFS) training provides an effective means to cultivate critical thinking skills, knowledge, clinical competency, and confidence that might otherwise take years to acquire due to the infrequent nature of real-life events (Wunder, 2016; Hawkins et al., 2014). Compared with verbal instruction, simulation promotes competency through kinesthetic learning (Hirshey-Dirksen et al., 2013). According to a study by Henrichs, Thorn, and Thompson (2018) in which simulation was used with student registered nurse anesthetists (SRNAs) to recognize and manage anesthetic emergencies, repeated simulation exposure at different intervals allows repetition and practice needed to develop and maintain competency in knowledge and problem-solving skills. Studies have shown various degrees of knowledge and skill retention after simulation (Hawkins et al., 2014; Tan et al., 2014) making the ideal frequency for retraining unclear. However, it is suggested that simulation training should be repeated after six months to one year for additional benefit (Orique & Phillips, 2018; Giuliano & McGregor, 2016).

Simulation with structured debriefing has the added benefit of increasing crisis management skills and knowledge retention (Cain, Riess, Gettrust, & Novalija, 2014; Cicero et al., 2012). Debriefing is a learner-centered

approach that allows learners the opportunity to reflect on and analyze their performance and receive feedback (Palaganas, Fey, & Simon, 2016). Structured debriefing at the end of simulation training allows learners an opportunity to assume a more active role during the learning process and increases the efficacy of the simulation training (Hirshey-Dirksen et al., 2013). Structured debriefing increased crisis management technical skills, critical thinking, knowledge retention, and nontechnical skills for up to five months after the intervention (Cicero et al., 2012).

Problem

Malignant hyperthermia is a low-frequency, high-impact event that many CRNAs may be unprepared to manage due to limited clinical experience and sole reliance on didactic education to manage the crisis (Hawkins et al., 2014; Hirshey-Dirksen et al., 2013). The American Association of Nurse Anesthetists (AANA) and the Malignant Hyperthermia Association of the United States (MHAUS) recommend that both novice and experienced CRNAs receive continuing education annually to maintain competency in managing MH (AANA, 2018; MHAUS, 2018). High-fidelity simulation combined with lecture and structured debriefing can assess learners' current skill levels, identify areas in need of improvement, and supply the learners with the repetition needed to acquire the knowledge and skills necessary to manage high-impact events such as MH in a safe learning environment (Hirshey-Dirksen et al., 2013).

Methods

Design

This quality improvement (QI) project used a pre-post test interventional design, with the test results as the primary outcome indicators. The purpose of this QI project was to improve CRNAs' ability to respond to an MH crisis. The specific aims of this project were to

- Successfully implement an HFS training exercise to improve CRNAs' MH knowledge base
- Assess CRNAs' technical skills with a Key Action Checklist; and
- Assess CRNAs' nontechnical skills with the anesthetists' nontechnical skills (ANTS) tool.

Organizational Setting

The setting for this QI project was an academic school of nursing simulation laboratory located in the Southeast United States. The simulation laboratory has two operating room suites that are equipped with computerized manikins, functional anesthesia gas machines, as well as audio-visual recording and viewing capabilities.

Sample

Participation was voluntary. A convenience sample of 16 CRNAs was obtained from clinical sites affiliated with the school of nursing's anesthesia program. Exclusion criteria included anesthesiologists, anesthesiology residents, anesthesia assistants, and SRNAs. Recruitment efforts included e-mail invitations to all CRNAs at clinical affiliates of the nurse anesthesia program and flyers posted in CRNA staff break rooms. As a volunteer recruitment incentive, the project committee secured AANA approval to award CRNA participants continuing education credits for completing all phases of the simulation experience.

Instrument

The didactic MH lecture was developed based on the most recent MH evidence and reinforced the disease process, pharmacology, and management of an MH crisis (AANA, 2018; Heytens et al., 2015; Hirshey-Dirksen et al., 2013; Lu et al., 2016; MHAUS, 2018; Rosenberg et al., 2015). The survey instrument included 15 multiple-choice knowledge questions selected from the MH didactic content and one question to assess self-confidence using a five-point Likert scale (Figure 1). The pretest, posttest, and three-month posttest contained 15 identical questions to allow for direct comparison between all tests. To determine the face validity of the 15 MH questions in the pretest, posttest, and three-month posttest, two MH content experts were consulted to ascertain if the questions addressed what they were intended to address. Did the questions allow the team to determine participants' level of understanding, comprehension, and MH knowledge? All tests were linked to the ANTS tool, Key Action Checklist, and real-time video recordings by participant's unique identifier code.

1	2	3	4	5
Not able to manage an MH crisis	Can manage an MH crisis with difficulty	Can manage an MH crisis with some difficulty	Can manage an MH crisis per standards with prompting	Can manage an MH crisis per standards without prompting

Figure 1 Self-confidence Likert scale. *Note*. Participants were asked to circle which statement best fits how they feel at a certain time in the training.

Participants' technical skills were assessed with a Key Action Checklist. The Key Action Checklist is a valid and reliable scoring system, originally developed by Murray et al. (2005), to evaluate participants' technical skills during simulated crisis management (McEvoy et al., 2014). The Key Action Checklist used in this QI project was adapted from the study by Murray et al. (2005) and was developed from the standard care MH guidelines set by the MHAUS and AANA (Table 1) (AANA, 2018; McEvoy et al., 2014; MHAUS, 2018). Each correct action performed or delegated appropriately by the participant correlated to one point, for a total of 20 points for 20 action items. If the task was performed incorrectly or not at all, the participant received a zero for the task. If a participant partially completed the task correctly and omitted a portion of the task, half a point was awarded for that task.

Participants' nontechnical skills were assessed using the ANTS tool. The ANTS tool contains 15 skill elements, which are rated from 1 (poor) to 4 (good). The four nontechnical skill categories equal the average of their corresponding skill elements. The ANTS tool is a valid and reliable tool developed by Flin et al. (2012), which is used to evaluate the nontechnical skills of

Table 1 Key Action Checklist

Step	Action/Treatment Checklist	Met	Partially Met	Did Not Meet
1	Inform surgeon to halt or finish surgery			
2	Turn off all MH-triggering agents and tape or remove vaporizer* and remove succinylcholine*			
3	Calls for help			
4	Ask for MH cart; cooling items; code cart			
5	Disconnects patient from AGM and hyperventilate with 100% O_2 at 10 L/minute with bag valve mask			
6*	Insert activated charcoal filter (optional); flush anesthesia machine accordingly			
7*	Starts TIVA			
8*	Calls MHAUS (1-800-644-9737)			
9	Calculates, reconstitutes*, and administers correct dantrolene dose* Reconstitution: 60 mL of sterile water/vial Administer: 2.5 mg/kg			
10*	Discontinues warming and activate cooling (stops cooling if temp is below 38°C)			
11	Monitor core temp (if already in place, need to state that it is in place)			
12*	Places A-line and/or central line (if already in place, need to state that it is in place)			
13*	Draws labs (Na, glucose, K+, Ca++, CK/myoglobin, lactic acid level, PT/PTT/FSP/D-dimer/fibrinogen, CBC/platelets, ABG)			
14*	Obtains more IV access (if already in place, need to state that it is in place)			
15	Treats metabolic acidosis 1-2mEq/kg Na bicarb for base excess > -8 (max dose 50 mEq)			
16	Treats arrhythmia (calcium channel blockers were not used)			
17	Repeat dantrolene dose in increments up to a total dose of 10 mg/kg until signs of MH are controlled			
18*	Places Foley (if already in place, need to state that it is in place) urine dipstick (Hgb/myoglobin)			
19	Maintains urine output > 1-2 mL/kg/h Treat with hydration and diuretics			
20	Transfers patient to ICU			

Note. MH = malignant hyperthermia; MHAUS = Malignant Hyperthermia Association of the United States.
* Tasks that can be delegated to another team member.
Source: Adapted from the concepts from Murray and colleagues' (2005) Key Action Checklist.

anesthesia providers in practice (Wunder, 2016). The observation on performance portion of the ANTS tool used in this QI project was prefilled with expected behaviors to offer raters clarity and consistency when rating participant's performance. This was adapted from the study by Flin et al. (2012) nontechnical skill guidelines and the MH guidelines established by the MHAUS (2018) and the AANA (2018).

Two raters scored the Key Action Checklist and ANTS tool during the simulation portion of this QI project. Each rater was instructed on the use of the Key Action Checklist and ANTS tool, given tool guidelines, and practiced using the tools during trial simulations before use with the MH simulation scenario. Both raters scored each participant's technical and nontechnical skills during the simulation. The generalizability coefficient (reliability estimate) for the simulation scores for the two raters was 0.94 on the Key Action Checklist and 0.86 on the ANTS tool.

Intervention

Participants began with a pretest to assess baseline MH knowledge and self-confidence level. Participants were then presented a 45-minute lecture on MH followed by an allotted 15 minutes for questions and answers. Next, participants were given a short prebrief to assure participant's safety, review equipment and supplies, and familiarize themselves with the simulated operating room environment. Finally, participants were invited to ask questions regarding the expectations for simulation training.

A wireless, high-fidelity, full-body manikin served as the simulated patient with the scenario that unfolded in real time from recognition to treatment. A CRNA participant served as the primary anesthetist and was accompanied by second- and third-year SRNAs in the nurse anesthesia program that played confederate roles of surgeon, surgical technologist, operating room nurse, and a second CRNA. Training began with an intraoperative report from the confederate CRNA who was going on break. The simulated patient was undergoing a laparoscopic sigmoid colectomy complicated by an MH crisis. During the scenario, participants were scored on their ability to recognize and manage an MH crisis, a fundamental concept that is taught in nurse anesthesia programs in conjunction with its treatment algorithm. Each CRNA acted as the lead anesthesia provider during the scenario and delegated tasks to the surgical team during the management of the patient. All simulation sessions were video-recorded, and each participant was rated by two primary raters on the Key Action Checklist and ANTS tools to decrease bias. The scenario ended when the CRNA stabilized and transferred the patient to the ICU. The scenario lasted approximately 15 minutes, followed by a 15-minute debriefing session.

A structured debrief, led by the project coordinator, was held immediately following the scenario with each participant individually using the Gather-Analyze-Summarize model. Individually, participants were encouraged to share observations and feelings about the simulation training. Next, participants discussed their performance during the scenario before giving feedback on how it compared with the standard of care. Overall feedback on their experience while managing the MH crisis was assessed, and any questions were resolved. After the debrief session, participants completed a posttest to measure self-confidence level and assess MH knowledge. Finally, participants completed an additional posttest, via e-mail, three months after the simulation scenario to assess whether concepts were retained and to assess self-confidence level. E-mail reminders for the three-month posttest were sent to participants at two different time points until the three-month posttest was completed.

Results

Data were collected from 16 CRNAs who volunteered to participate in this QI project. All analyses were performed using SPSS Statistics software (version 24.0; SPSS Inc., Chicago, IL). A repeated-measure analysis of variance for independent groups was conducted to test for significant

Table 2 Participant Demographic Information

Participants Characteristics	*n* (%)
Age (year)	
≤25	0 (0)
26-30	1 (6)
31-35	3 (19)
36-40	2 (12)
41-45	3 (19)
46-50	0 (0)
51-55	3 (19)
>55	4 (25)
Gender	
Male	5 (31)
Female	11 (69)
Number of years practicing as a CRNA	
≤2	2 (12.5)
3-5	3 (19)
6-10	2 (12.5)
11-15	1 (6)
16-20	2 (12.5)
21-25	2 (12.5)
>25	4 (25)
Have you ever experienced (or participated) in an MH crisis or suspected MH crisis?	
No	14 (87.5)
Yes	2 (12.5)
Have you ever participated in a high-fidelity simulation training?	
No	10 (62.5)
Yes	6 (37.5)

between-group differences in mean MH knowledge scores and participants' mean self-confidence levels. A multiple comparison test was conducted to further examine score differences among mean MH knowledge scores and mean self-confidence levels. Descriptive statistics were used to evaluate ANTS and Key Action Checklist scores.

General categorical demographic questions collected data including participants' age range, gender, number of years practicing as a CRNA, number of previous HFS experiences, and number of experiences with MH crises (Table 2). In total, 12 of 16 (75%) participants completed all knowledge tests and confidence level assessments. A significant difference between groups was seen among mean MH knowledge scores (F [1,11] = 1749.28, $p < .001$). The mean MH knowledge posttest (14.42/15 ± 0.99; 95% confidence interval [CI] = 13.78, 15.05) revealed a 2.3-point ($p < .001$) increase compared with the mean MH knowledge pretest (12.08/15 ± 1.56; 95% CI = 11.09, 13.08). The mean MH knowledge three-month posttest (12.75/15 ± 1.49; 95% CI 11.81, 13.69) decreased by 1.67 points from the posttest ($p = .003$). A comparison between the mean MH knowledge pretest and three-month posttest was not significant ($p = .07$), but the mean three-month posttest scores remained 0.67 points higher than the mean pretest scores (Figure 2).

There was a significant effect attributable to self-confidence levels (F [1, 11] = 532.12, $p < .001$). The analysis showed that the mean pretest self-confidence level was 3.00/5 (SD ± 0.95; 95% CI = 2.39, 3.61), the mean posttest self-confidence level was 3.67 (SD ± 0.65; 95% CI = 3.25, 4.08), and the mean three-month posttest self-confidence level was 3.75 (SD ± 0.62; 95% CI = 3.35, 4.15). Although self-confidence levels continued to increase, there was no significant comparison between the self-confidence levels of the pretest and the three-month posttest (all $p > .05$) (Figure 3).

Technical skills performance, as measured by the Key Action Checklist, revealed that, overall, CRNAs achieved a mean score of 16.99 (SD ± 1.98) out of 20 possible points. Nontechnical skills performance, as measured by the ANTS tool, revealed that CRNAs scored a mean of 3.52 (SD ± 0.39) during simulation training. Further analysis revealed that the number of years practicing as a CRNA did not significantly correlate with an increase in pretest knowledge, ANTS, or Key Action Checklist scores (all $p > .05$). However, ANTS scores were significantly higher in those with previous simulation experience ($p = .02$) but was not significant in the Key Action Checklist ($p = .06$) or MH knowledge pretest scores ($p = .67$).

Discussion

As part of this QI project, a simulation scenario and associated scoring rubrics were developed to evaluate a participant's knowledge and skills, nontechnical and technical, in managing an MH crisis. Overall, findings revealed that CRNAs scored a mean of 80% on the MH knowledge pretest, with the lowest score being 8 (53%) and the highest score being 15 (100%) out of 15 questions. These scores showed that participants overall had a good understanding of MH. Further analysis of the MH knowledge questions revealed that most questions missed on the pretest were related to dantrolene pharmacology. After the didactic education session and simulation, participants' mean MH knowledge scores increased by 2.3 points, for a mean of 14.42 (96%) out of 15. During the three-month posttest, participants' scores decreased by 1.67 points yet remained higher than pretest mean scores (Figure 2). This showed that the simulation training and lecture increased and maintained MH knowledge for three months with statistical significance. Although studies included in Orique and Phillips (2018) meta-analysis showed a longer period of knowledge retention, this could be attributed to the fact that many of these studies conducted repeated, multiple-approach education sessions compared to the single, two-hour session for this project. Further analysis of this project's three-month MH knowledge data revealed that participants primarily missed dantrolene pharmacology questions, suggesting that dantrolene pharmacology education should be reinforced more frequently. Thus, biannual dantrolene pharmacology education sessions may be more beneficial than annual education sessions. Furthermore, CRNAs may benefit from biannual education with the newer formulation, Ryanodex.

According to the self-confidence assessment, CRNAs reported that they felt more prepared for an MH event should one occur after completing this training session. Although not statistically significant, self-confidence levels continued to increase from pretest to the three-month posttest (Figure 3). A meta-analysis by Orique and Phillips (2018) revealed that self-confidence in skills and knowledge continues to increase with repeated exposure.

Analysis of participants' technical skills revealed that CRNAs scored a mean of 85% on the Key Action Checklist. The high scores may have been because participants knew the scenario they would receive before entering the simulation laboratory; they were not blinded as in other studies. Furthermore, the Key Action Checklist used in this QI project had 20 items compared to previous studies that had less than 10 items. Analysis of participants' nontechnical skills revealed that CRNAs scored a mean of 3.53 out 4 on the ANTS tool. This correlates with an overall "acceptable" performance on the behavioral tool. Further data analysis suggests that more instruction may be needed on task management skills during future nontechnical skills training.

Participants with past simulation training scored significantly higher on nontechnical skills but not significantly higher on technical skills compared with participants with no past simulation training. In this QI project, the number of years practicing as a CRNA did not significantly

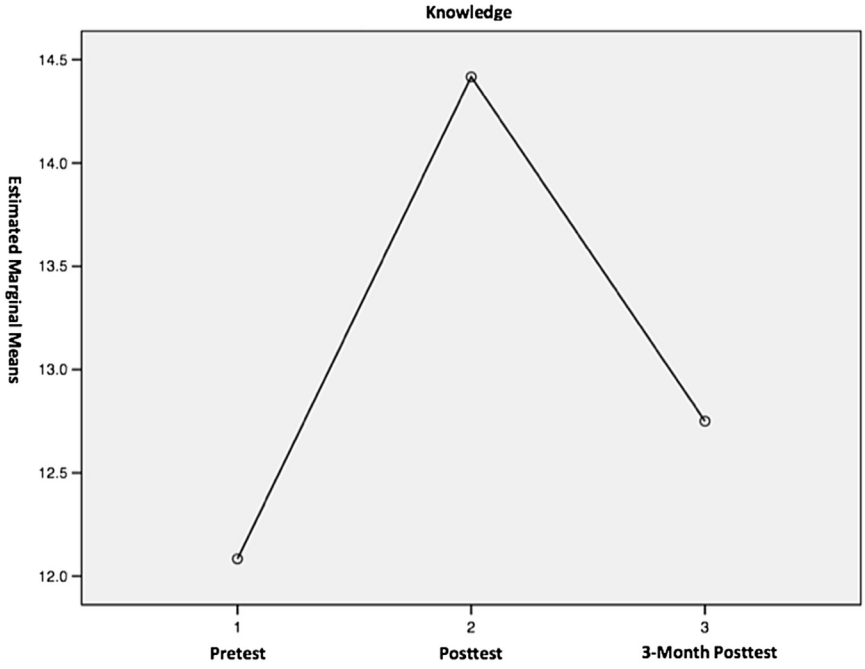

Figure 2 MH knowledge scores. *Note*. MH = malignant hyperthermia.

correlate with higher scores in knowledge, nontechnical skills, technical skills, or confidence. Conversely, in a study by Henrichs et al. (2009), anesthesia providers with more clinical experience produced higher scores. These findings could be due, in part, to the fact that participants with past simulation experience felt more comfortable in the simulation environment compared to participants with more clinical experience but less simulation experience. Alternatively, the variability in our findings may have affected results due to a small sample size (n = 16). The postimplementation survey also revealed that CRNAs prefer annual MH simulation training in clinical groups at their facility in a more familiar setting rather than a remote, unfamiliar simulation laboratory.

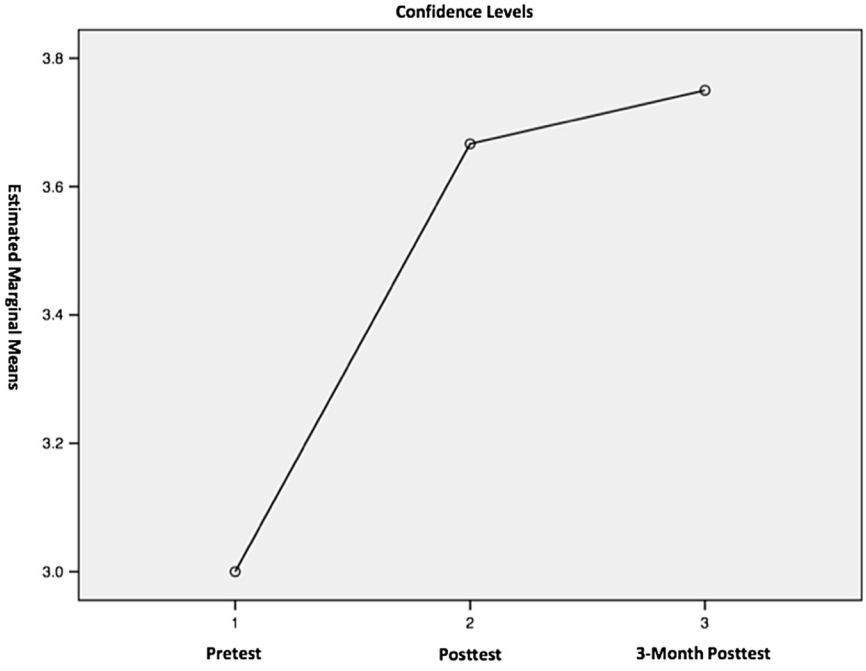

Figure 3 MH self-confidence. No color is needed. *Note*. MH = malignant hyperthermia.

Limitations

Over 200 invitations were sent out to CRNAs to participate in this QI project; however, only 16 CRNAs agreed to participate. Consequently, this group of participants may not adequately represent the CRNA population. Scheduling issues with participants may have contributed to a small implementation window and a limited sample size. Time constraints also limited options for a repeat of CRNAs' nontechnical and technical skills testing as well as the options for increasing the return rate (75%) for the three-month posttest. Because of this, the QI project focused more on knowledge scores and self-confidence levels than technical and nontechnical skills scores over time. A cross-sectional analysis of participants' performances should be conducted with a longitudinal analysis after participants' performances over the course of the simulation training with repeated measures. This would help determine if skills and knowledge changed among participants and show the effectiveness of the simulation training after repeated exposure. Although the American Society of Anesthesiologists (2018) does not specify a desired number of repetitions needed to master a given skill, the organization clearly notes that isolated exposures do not lead to skill retention (Lien, Warner, & Rathmell, 2017). The results from this QI project showed that knowledge, self-confidence, technical skills, and nontechnical skills were similar to those reported in comparable simulation training studies (Orique & Phillips, 2018; Tan et al., 2014, Wunder, 2016).

Although HFS that mimics the physiologic and pharmacologic aspects of a real-time scenario can be used to effectively create realistic training environments, the findings of this project are based on performance in a simulated environment and may not fully reflect clinical performance. Factors such as motivation, assessment anxiety, unfamiliarity with the simulator and anesthesia simulator equipment (Hawkins et al., 2014), and the inability to suspend disbelief (Muckler, 2017) may have affected participants' performances in this QI project. As a result, simulation findings may not accurately reflect actual clinical abilities. According to the study by Hawkins et al. (2014), CRNAs may avoid participating in simulated activities due to the perceived stress associated with simulation performance, fear of repercussions for poor simulation performance, time requirements, and distance to the simulation laboratory. It has been suggested that in situ simulation training may be a solution to this as it allows participants to train in a close, more familiar environment (Herbers & Heaser, 2016; Sorensen et al., 2017). Finally, most CRNAs who participated in this QI project work in anesthesia care team models. The MH scenario required CRNA participants to work as autonomous anesthesia providers, which did not reflect all participants' daily practice environment and may have been less instinctive and posed challenges for some participants.

Conclusion

Malignant hyperthermia is a complex event that may result in delayed or missed recognition, incomplete application of best practice guidelines, and possibly death. Periodic education and arbitrary clinical experience are insufficient to prepare CRNAs to optimally manage an MH crisis in a timely and comprehensive manner. The CRNA often functions as a team leader in a perioperative emergency and must maintain current clinical knowledge and skills required to efficiently and effectively manage such emergencies. Thus, simulation-based training is a teaching adjunct that complements provider preparedness, knowledge, nontechnical skills, and technical skills needed to manage an MH crisis. Although few studies examine CRNAs' knowledge and performance when managing a simulated MH crisis, this training opportunity allowed participants to identify MH knowledge gaps and practice technical and nontechnical skills needed to provide prompt, targeted, and effective management of an MH crisis.

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