Pediatric Code Blue: How Prepared Are We? A Self-Efficacy Assessment Project

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Abstract

Pediatric advanced life support (PALS) recertification every two years is inadequate to maintain proficiency. The authors hypothesized that a standardized, recurring curriculum may enhance retention of cardiopulmonary resuscitation (CPR) skills. Monthly in situ *mock code training and an annual online self-directed learning module were implemented for pediatric intensive care unit nurses, pediatric residents, and respiratory therapists at a women and children's hospital. The* in situ *mock codes were linked to PALS training self-efficacy (pre- and post-mock code) and feedback related surveys. CPR knowledge was assessed using an online module with pre- and post-tests. A total of 82* in situ *mock code surveys and 137 online modules were completed over a 20-month period. Medical knowledge (*P < *.05 for 7/10 questions) and self-confidence improved (*P < *.001. Several staff reported a negative impact on their patient care assignments in order to participate in the mock code. However, a significant number of participants (65%) concurred with the benefits of monthly mock codes. The curriculum improved CPR efficacy by improving knowledge-based retention as well as self-confidence in their skills.*

Keywords

Cardiopulmonary resuscitation, PALS, Pediatric advanced life support, Refresher, Self-efficacy

Abbreviations

AHA = American Heart Association
CPR = Cardiopulmonary resuscitation
KMCWC = Kapi'olani Medical Center for Women and Children
PALS = Pediatric advanced life support
PICU = Pediatric intensive care unit
RN = Registered nurses
RT = Respiratory therapists

Introduction

Cardiopulmonary resuscitation (CPR) is a crucial aspect of pediatric critical care. First responders during pediatric code blue often are pediatric residents, pediatric nurses, respiratory therapists, and other providers who are not pediatric critical care or pediatric emergency trained physicians. The American Heart Association (AHA) recommends Pediatric advance life support (PALS) recertification every two years. Unfortunately, PALS training skills and knowledge are often not sustained for the full two-year recertification interval.[1,2] A variety of PALS curricula have been introduced; however, none are endorsed by the AHA or otherwise standardized.[3-6] These curricula are important for the retention of knowledge and skills required to utilize PALS algorithms. Self-efficacy, confidence, familiarity, communication, and delegation of tasks are also important aspects of pediatric CPR to ensure successful outcomes.[1,3,7] Hence, it is imperative to address those aspects as well in CPR related training.

The infrequent occurrence of in-hospital cardiac arrests also limits the providers' efficacy to maintain CPR skills.[1] The experience at our institution would support this conclusion. In 2016, there were 54 pediatric and 5 adult code blue events. A total of 26 events occurred in the Neonatal Intensive Care Unit, 15 in the pediatric intensive care unit (PICU), 10 codes in the Emergency Department, 1 in the Post-Anesthesia Care Unit, 2 in the Adult ICU, 2 in the Family Birth Center, 2 in the pediatric ward unit, and 1 in the Operation Room. Members of the pediatric code blue team respond to all events throughout the hospital. The team is comprised of PICU registered nurses (RN), PICU respiratory therapists (RT), a pediatric emergency physician, and pediatric residents. There are approximately 45 PICU RN, 58 respiratory therapists (RT) and 25 pediatric residents. This exposure to actual code events is insufficient for pediatric code blue team members to master and maintain the various PALS algorithms for resuscitation. This is in conjunction with the authors' belief that PALS recertification required every two years is too infrequent. Therefore, the goal was to create an educational curriculum to bolster the confidence and performance of the pediatric code blue team members.

In October 2017, a blended learning recurring PALS curriculum was created with two components. The first component was a monthly *in situ* mock code in the PICU to sharpen the CPR related practical skills and to augment the self-confidence of the participants. The second component was an annual online learning module which would enhance CPR-related medical knowledge through hypothetical scenarios, followed by questions testing acquired knowledge. It has been suggested that even well-trained providers may not be able to apply their skills and knowledge during the code if they lack self-confidence.[3] Hence the objective was not only to enhance medical knowledge and CPR skills, but to also increase self-confidence. The hypothesis was that by addressing these three components through a blended learning curriculum, the self-efficacy of pediatric code blue team members would be enhanced.

Methods

This study was performed at Kapi'olani Medical Center for Women and Children (KMCWC). It is the only tertiary care referral hospital in the entire state of Hawai'i providing comprehensive obstretic and pediatric care. KMCWC is also dedicated to research and medical education. The curriculum was composed of two components: monthly *in situ* mock codes and an annual online learning module. The first mock code was conducted in October 2017 and continued monthly whenever possible. A total of 15 mock code surveys were conducted during this 20-months' study period. The annual online module was started in December 2017. Participants consisted of PICU RN, RT, and pediatric residents rotating through the PICU.

The monthly *in situ* mock codes were conducted in the PICU by the attending physician, a pediatric nurse educator, and a clinical system trainer. A PICU pharmacist was present as support staff but did not participate in the mock code or the survey. Each mock code team consisted of 1-3 pediatric residents, 1-2 PICU RN, and 1-2 PICU RT. These were unannounced events and were not part of the routine PICU training program. The 20-minute active case management simulation *in situ* mock code was conducted using a Pediatric HAL® S3005, Wireless and Tetherless, Five-Year-Old Patient Simulator (Gaumard: Miami, FL). The scenarios were based on select PALS course cases including shock and cardiac dysrhythmias. The learning activities included chest compression, bag-mask ventilation, endotracheal intubation, medication preparation and administration, fluid resuscitation, and synchronized cardioversion and/or defibrillation. Following the in situ mock code, direct feedback was provided using a PALS- based structured debriefing. An anonymous PALS self-efficacy pre- and post feedback survey was completed by all participants. The self-efficacy survey included the participant's level of familiarity or comfort with (1) being part of the code blue team, (2) drawing medications during the code, (3) performing chest compression, (4) providing bag mask ventilation, (5) performing or assisting with endotracheal intubation, and (6) using the defibrillator device. A scale of 1-5 was used to rate the level of familiarity for each skill, with 5 representing the most familiar and 1 the least. The ratings for both pre- and post-mock code surveys were recorded on the same anonymous form for each participant, allowing for paired comparisons. The feedback component included (1) the participant's opinion on the optimal frequency of the mock code sessions, (2) the extent to which, if any, participation in the mock code affected their patient care duties, and (3) the quality of the debrief.

The second component of the curriculum was an annual online module where PICU RNs navigated through a small didactic session. This consisted of 15 non-narrated slides. They were designed to take 20 minutes to complete in a self-paced, independent learning environment. There were no clinical scenarios included in the teaching part of the module. The questions, however, tested the trainee's knowledge using clinical scenarios. The specific content of the modules and the questions included CPR principles, management of shock and dysrhythmia, and the science of resuscitation. The scoring was recorded for each individual and a minimum of 80% correct answers was required to pass the post-test. The rationale for selecting an 80% passing score was based on pilot testing of pediatricians, pediatric residents, and senior PICU RN. The questions in the pre-test and the post-test were identical; correct answers were provided at the conclusion of the post-test. Only PICU RNs participated in the online curriculum during the first year. The same curriculum was repeated the next year and all the RNs participated in the curriculum.

The mock code events and the online modules were approved by the Quality Improvement Committee of the institution. All surveys and the test questions were anonymous. Accordingly, Institutional Review Board exemption was obtained prior to the initiation of this project. Results of all participant surveys were analyzed. Since the PICU RNs group participated in both annual online module and monthly in situ mock codes, a subgroup analysis of PICU RNs was carried out for the PALS self-efficacy survey. The goal of this subgroup was to determine the impact of the annual online module on the in situ mock code survey results. Another subgroup analysis investigated the impact of repeat participation in the in situ mock code.

Statistical Analysis: Fisher's exact test for online module survey (categorical variables) and a Wilcoxon signed rank test for PALS training self-efficacy survey (non-parametric) were performed using a GraphPad Prism version 8.0.0 (GraphPad Software: San Diego, CA). A two tailed P-value of $< .05$ was considered statistically significant.

Results

Survey results over 20 months from October 2017 through May 2019 were analyzed. There were a total of 82 PALS training self-efficacy and feedback surveys from participants in 15 in situ mock codes. Those who completed the surveys included 25 pediatric residents, 42 PICU RNs, 14 RTs, and 1 PICU nurse academy student (Table 1). A total of 14 participants repeated the mock code activity at least once during the study period.

Table 2 shows the results of the PALS training self-efficacy survey. The numbers represent the mean level of familiarity

Table 1. Designation of the *in situ* Mock Code Participants

Participant Designation	Number of Participants
Pediatric Residents	25
PICU RNs	42
PICU RTs	14
PICU Nurse student	1

or comfort of all first-time participants for six skills, using a scale of 1 to 5 (highest), prior to and after the mock code. They represent the results from the entire cohort participating in the in situ mock code. Table 2 also shows the first subgroup analysis for the PICU RN, who participated in the annual online module in addition to the monthly in situ mock codes. The second subgroup analysis includes those who participated in in situ mock codes more than once. This second subgroup included 12 PICU RNs, 1 PICU RT, and 1 pediatric resident.

In relation to the feedback component of the mock code survey, the authors requested the opinion of the participants regarding the optimal frequency of the in situ mock code. Of the 82 valid responses, 17% responded once a week, 65% responded once a month, 14% responded once every 3 months, 2% responded once every 6 months, 1% responded once a year, 1% deferred to respond and no one responded not at all. This study also asked if participation in the mock code affected the patient care assignment for that day. Of the 82 valid responses, 26% responded: "Yes", 39%responded "No", and the remaining 35% deferred to respond. The mean reported effectiveness of the debrief for all mock codes was 9 on the scale of 1 to 10.

The number of participants for the online modules was 69 in 2017 and 68 in 2018, totaling 137 participants completing the module and the test (Table 3). Improvement in the post-test score was statistically significant for 7 of 10 questions for the combined 2-year analysis. Ninety-five participants filled out module specific surveys for the feedback to the organizers. Of the 95 valid responses, 37% responded that the module was extremely helpful, 36% responded that it was very helpful, 27% responded that it was helpful, and no one responded that it was not helpful. Of the 95 valid responses, 2% responded that the module was too easy, and 98% responded that it was appropriate for the level of training, and none responded that it was too difficult. No one reported any commercial bias. The discrepancy in the number of participants in the pre- and the post-test resulted from some participants requiring more than one attempt to pass the test.

Table 2. PALS Training Self-efficacy for Level of Familiarity of the Participants on Six Skills on the Scale of 1 to 5

Survey item	Pre-mock code (mean)	Post-mock code (mean)	*P* value[a]
Being part of the team			
All participants (n=82)	3.03/5	3.63/5	<.001
PICU RN subgroup (n=42)	2.83/5	3.60/5	<.001
Repeat participants subgroup (n=14)	3.14/5	3.79/5	.008
Drawing medication			
All participants (n=82)	2.72/5	3.13/5	<.001
PICU RN subgroup (n=42)	3.20/5	3.73/5	<.001
Repeat participants subgroup (n=14)	3.00/5	3.64/5	.130
Doing chest compression			
All participants (n=82)	3.90/5	4.18/5	<.001
PICU RN subgroup (n=42)	3.71/5	4.12/5	<.001
Repeat participants subgroup (n=14)	3.83/5	4.00/5	.25
Providing bag mask ventilation			
All participants (n=82)	3.88/5	4.07/5	<.001
PICU RN subgroup (n=42)	3.54/5	3.91/5	.004
Repeat participants subgroup(n=14)	3.50/5	3.73/5	.50
Doing/assisting endotracheal intubation			
All participants (n=82)	3.47/5	3.68/5	<.001
PICU RN subgroup (n=42)	3.32/5	3.56/5	.008
Repeat participants subgroup (n=14)	3.45/5	3.70/5	.25
Using defibrillator during code			
All participants (n=82)	2.72/5	3.39/5	<.001
PICU RN subgroup(n=42)	2.83/5	3.43/5	<.001
Repeat participants subgroup (n=14)	2.79/5	3.46/5	< .031

[a] Based on the Wilcoxon signed rank test.

Table 3. Correct Answer in Percentage for Online Module Knowledge Analysis, Before and After the Training Module (Pre- and Post-test)

	Years 2017-2018			Years 2018-2019		
	Pre-Test (n=69)	Post-Test (n=78)	*P* value[a]	Pre-Test (n=68)	Post-Test (n=74)	*P* value[a]
Question 1	46.38%	97.44%	<.001	44%	93%	<.001
Question 2	59.42%	94.87%	<.001	79%	100%	<.001
Question 3	62.32%	96.15%	<.001	82%	95%	.032
Question 4	23.19%	85.90%	<.001	37 %	86%	<.001
Question 5	31.88%	67.95%	<.001	19%	65%	<.001
Question 6	52.17%	83.33%	<.001	56%	95%	<.001
Question 7	73.91%	87.18%	.057	79%	88%	.254
Question 8	65.22%	80.77%	.040	78 %	85%	.286
Question 9	56.52%	92.31%	<.001	66%	99%	<.001
Question 10	37.68%	97.44%	<.001	51%	99%	<.001

[a] Based on the Fisher exact test

Discussion

This study revealed that a 20-month program of a blended PALS learning curriculum enhanced self-efficacy of pediatric code blue team members. Specifically, results of monthly in situ mock codes showed a significant increase in familiarity with CPR associated skills. In addition, the annual online module was associated with improved CPR related medical knowledge in the RN team members. These results support the study hypothesis, and in doing so address the three key components considered essential to resuscitation training; namely medical knowledge, CPR skills, and self-confidence.[1] Furthermore, the program addressed gaps in pediatric resident training,[1-3] and the authors anticipate it will enhance long-term CPR-related patient outcomes.

The results are similar to those of several published studies.[4-6] One study reported increased comfort and knowledge in pediatric residents after a one-year program of mock codes.[4] However, this study lacked any complementary on-line educational tools. Further, the authors reported that anonymous surveys limited their ability to utilize paired statistics. In contrast, mock code surveys in the present study were also anonymous, but participants filled out the pre- and post-mock code surveys on the same form, facilitating the use of paired statistics. Another office-based, 2-step curricula showed increased provider confidence and decreased anxiety related to actual code events. The curricula used in this study was similar to the present one, including educational didactic and in situ mock codes.[5] Another office-based quality improvement program including mock codes showed improved emergency preparedness and CPR related skills. Neither level of familiarity nor anxiety were evaluated in that program, although the concept of unannounced mock code was well received.[6]

Subgroup analysis was performed on two separate components. First, an analysis was performed on PICU RN, since they represented the only team members participating in both online module and in situ mock code. The results of this subgroup were found to be similar to the full cohort of participants. Thus, although the annual on-line module improved CPR knowledge, it had little impact on performance of the PALS self-efficacy post-mock code survey. Clearly, while complementary in nature, different skill sets were tested after the on-line module to those of the mock code. Another subgroup analysis involved the members who participated in more than one in situ mock code. There were notable differences found after repeat participation, which the authors believe were artifactual in nature. This was a result of the higher scores found with certain skills in the repeat participant group, both prior to and after the mock code. It is believed this represents an accumulated "level of familiarity" gained during the previous mock code, rather than any alternative explanation. Finally, pre-test scoring of the online module was higher after repeating it in the second year as compared to the first year, again suggesting an accrued retention of medical knowledge from first year participation.

There were several limitations of this study including the modest sample size and lack of control group. Another weakness was the in situ mock code surveys were subject to individual and subjective interpretation. A final concern was the inability to conduct the in situ mock codes predictably on a monthly basis, as envisioned. Naturally, since patient care is the ultimate concern of any hospital unit, the ability to conduct monthly mock codes was dependent upon the actual census and patient acuity in the PICU. Mock code participation also competed for staff time dedicated to patient care duties. Indeed, 21 (35%) participants reported a negative impact on their patient care assignments while participating in mock codes. Nevertheless, the majority of the participants (65%) touted the overall benefits of the monthly mock codes. Clearly, it was concluded that conducting in situ mock code was appropriate and of overall benefit for the PICU.

One concern regarding pre- and post-mock code scoring deserves attention. Although the focus of the mock code was a practical hands-on simulation review of the cognitive, manual, and team interactions required during active resuscitation utilizing the PALS algorithms, participants typically gravitated to their respective professional roles according to their specialty. Thus, certain questions in the mock survey may not be as relevant to certain specialties which may lead to misleading conclusions. For example, scores for drawing medication were typically high, while scores for bag mask ventilation and intubation were lower for the RN team members as compared to the full group of participants. Although it would be ideal to have all team members versed in all aspects of resuscitation, this may not be a realistic expectation. Future refinements in the mock code survey should consider factors related to individual staff roles and responsibilities.

It is also important to reveal that certain skills were not graded or analyzed such as bag-mask ventilation and chest compression. However, fundamental knowledge of these skills was tested in the online learning module. The authors also provided direct feedback to the participants on the effectiveness of bag-mask ventilation and chest compression during each mock code; however, these considerations were not included in the results or analysis. This is consistent with the design and analysis of previous studies.[4-6] Other parameters, such as participant "years of experience" and history of participation in real and mock codes, were not factored into the analysis. Sequencing of interventions, such as having an instructional session precede the mock code experience, has been proven beneficial in critical care.[8] There is recent evidence that the "flipped classroom approach" has also been of value in graduate medical education.[9] In either case, a fully engaged sequential instructional program was beyond the scope of the present study. A blended learning curriculum was utilized, focusing all team members

as active participants in the process of simulated resuscitation, with sharing of experiences, and the application of skills and knowledge.[9] The on-line learning module was tested on a subset of participants, the RN's, to determine the acceptability and value of including and or expanding this component in future iterations of this quality improvement project.

In conclusion, the PALS curriculum played an important role in cementing knowledge and self-efficacy of pediatric code blue team members at KMCWC. Monthly participation in utilizing in situ mock codes and completion of annual online modules were appreciated and well received. The interest in retaining CPR skills, knowledge, and confidence opens new opportunities for future research aimed at optimizing outcomes of children undergoing CPR. Future hospital-wide expansion of mock codes will include other pediatric units, increasing the use of the on-line module to include all health care workers participating in code blue activities. The pre- and post-test mock code survey will also be modified to factor code blue team roles as a modifying factor. Finally, the formalization of this blended recurring PALS curriculum will satisfy educational gaps in the field of pediatric CPR training.

Conflict of Interest

None of the authors identify a conflict of interest.

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