WEB PAPER

Initiation of a pediatric mock code program at a children's hospital[1]

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Abstract

Background: Pediatric cardiopulmonary arrests are rare. Mock codes were instituted to bridge the gap between opportunity and reality.

Aim: The goal was to improve medical caregivers' skills in pediatric resuscitation.

Methods: All pediatric and internal medicine/pediatric (med/peds) residents were anonymously surveyed pre- and post-intervention about confidence level about codes and code skills. Twenty mock codes were conducted during the 1 year intervention period. Statistical comparisons were made between each resident pre- and post-survey, graduating third-year residents (PGY3s) prior to intervention versus PGY3s with mock codes and pediatric versus med/peds residents.

Results: All residents significantly improved in their perception of overall skill level during the study ($p < 0.0001$). PGY3s were significantly more confident in their skills than PGY2s or PGY1s and PGY2s were significantly more confident than PGY1s both pre- and post-mock codes ($p < 0.0001$). Med/peds residents were significantly more confident in their skills than pediatric residents both pre- ($p = 0.041$) and post-intervention ($p = 0.016$). The two skills with the lowest score post-intervention were the ability to place an interosseous line and the ability to manage cardiac dysrhythmias.

Conclusions: Pediatric mock codes can improve resident confidence and self-assessment of their resuscitation skills. Data from surveys such as this can be used to design future skill-based educational initiatives.

Introduction

Pediatric cardiopulmonary arrests are rare events. Children often arrest secondary to hypoxia due to respiratory failure or shock unlike adults who arrest primarily due to cardiac etiologies (Schoenfeld & Baker 1993). If hypoxia is not treated and reversed, respiratory failure will progress to cardiac failure and death will rapidly ensue. Survival rate to hospital discharge is 27% from an in-hospital cardiac arrest and is 12% from an out-of-hospital cardiac arrest, with 15% and 4%, respectively, being neurologically intact (Donoghue et al. 2005; Nadkarni et al. 2006). Prevention of pediatric cardiac arrest is imperative and requires that appropriate therapy begin immediately. Most children who arrest experience hours of subtle decline. Improvements in outcome can be achieved if patients are treated at this earlier stage (Sharek et al. 2007).

Although many health care providers are trained for pediatric cardiopulmonary resuscitation (CPR) using Pediatric Advanced Life Support (PALS) courses, there is a gap between training and performance (Eisenberg et al. 1983). Moser & Coleman (1992) found that 2 weeks after training, CPR skills begin to deteriorate and continue to decline, reaching pretest levels by 1–2 years. Mannequin simulation with feedback within 6 months of initial training and at 6 month intervals can improve skill retention. Frequent use of CPR on an actual patient may not improve skill retention as the performance does not benefit from feedback and correction of errors (Deliere & Schneider 1980).

Practice improves performance. As patient volume increases, an institution generally improves its outcomes. This has been shown in many medical disciplines such as cardiovascular surgery (Young et al. 2007), orthopedic surgery (Shervin et al. 2007) and neonatal intensive care (Phibbs et al. 2007). Unlike many areas of medicine, resuscitation often

Practice points

- Pediatric cardiopulmonary arrest are rare events and in general pediatric residents do not feel adequately prepared for these events without practice outside of PALS.
- Mock codes offer an opportunity to practice rare events and allow an institution to evaluate its response as a system.
- Mock codes may not be the most efficient way to educate individual residents about resuscitation and other simulation opportunities need to be devised.
- Interosseous line placement is a unique and potentially life saving skill that is felt to be a weakness by many pediatric residents.

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demands the immediate recall of knowledge and skills without the luxury of time or consultation with written material or specialists. Because pediatric arrests are rare, practice must come from avenues other than through exposure during direct patient care. One such teaching opportunity is mock codes.

Mock codes allow hospital-wide practice of emergency situations in a supportive but realistic environment, thus creating a climate conducive for adult learning. The goals of this program are to increase the code team exposure to codes, to improve teamwork and communication of this multi-disciplinary team and to discover inefficiencies in the code response process before they impair patient care. Cappelle & Paul (1996) conducted the only known randomized, control trial of pediatric mock codes with 33 pediatric residents. Their study demonstrated that mock codes were helpful in improving resident self-confidence with code skills over the 4-month study period. This trial expands upon their trial by implementing hospital wide mock codes with activation of the entire code team allowing discussion of system-wide problems and improvements, evaluating different levels of residents as well as evaluating perceptions of differences in code skills between pediatric and combined internal medicine/pediatric (med/peds) residents.

Methods

This study was approved by the institutional review board at the University of Alabama of Birmingham. All pediatric and med/peds residents were surveyed pre- and post-intervention. The survey was modeled after the work by Cappelle & Paul (1996) and consisted of two domains both scored on a 5-point Likert scale. Part A contained four questions concerning attitudes about codes; Part B included 10 self-assessment questions on PALS skills (Appendix A). Residents were assigned a unique identifying number on their survey which was unknown to the investigators. This allowed comparison of individual residents pre- and post-intervention.

Bimonthly mock codes were performed over a 12-month period, July 2003–June 2004 in diverse patient care areas. Each mock code was videotaped by a professional photographer. Code response times for participants, times to initiate resuscitation components and appropriate use of drugs/equipment were recorded using a standard checklist by a single author (BM) (Appendix B). Four review sessions with all residents were held where 12 of the videotaped mock codes were critiqued. The code team at our institution is comprised of two residents and one intern. In addition, two nurses, one from the pediatric intensive care unit (PICU) and one from the emergency department, a respiratory therapist, a pharmacist, a pediatric surgical fellow, a chaplain, a radiology technician, and a laboratory technician respond to codes. Each mock code was activated in the usual manner without any advanced warning to team members that a simulated patient would be involved. Only the investigators had advanced warning. Each mock code consisted of a 10–15 min scenario based on common pediatric codes at our institution and a 5–10 min debriefing session immediately following with all code team participants. Risk management was also present at all codes to review any system-based issues that arose.

Scores from the survey of resident classes (Post-graduate year (PGY) 1, 2, 3) were compared using a one-way analysis of variance. Med/peds residents' survey scores were compared to those of pediatric residents using an independent *t*-test. Second- and third-year med/peds residents' scores were compared with those of second-year pediatric residents. Residents were compared to themselves using a paired samples *t*-test. All tests were two-tailed and a p-value <0.05 was considered significant. SPSS 11.5 (Chicago, Illinois) was used for analysis.

Results

Twenty mock codes were performed during the study period. Fourteen occurred in patient care areas including 11 on non-intensive care units, one in the PICU, one in the intermediate care unit and one in the burn unit. Six occurred in other areas including the pulmonary outpatient clinic, sleep laboratory, nuclear medicine suite, magnetic resonance imaging suite, outpatient dialysis unit, and the cafeteria. Nineteen of the twenty mock codes were videotaped. The mock code in the cafeteria was not videotaped secondary to privacy concerns. The time of the day varied from 8:00 am to 11:30 pm.

The pre-mock code survey return rate was 78/85 (89%); the post-mock code survey return rate was 48/66 (72%). The return rate was equivalent among PGY groups. Graduating PGY3's only participated in the pre-mock code survey. All residents had participated in a PALS course just prior to their PGY-1 year and at the end of their PGY-2 year.

Ninety percent of pediatric residents felt that they needed more knowledge about codes, 94% felt they needed more experience with codes and only 25% felt they knew the PALS algorithms. The worry index was calculated as the sum of the first three questions in Section A of the survey (Appendix A). The range of scores was 3–15, with 15 indicating a high level of worry about codes and need for more knowledge and experience. Figure 1 shows the average confidence level of PGY3's was significantly higher than PGY2's and PGY1's both pre- and post-mock codes ($p<0.0001$). The skills index

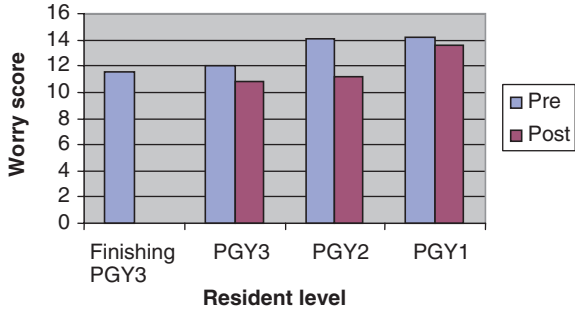

Figure 1. Worry index = codes scare me + I need more knowledge about codes + I need more experience with codes (range 3 (disagree) to 15 (agree)), MC = mock codes, PGY = post graduate year. Resident level is at the start of the indicated PGY, except for finishing PGY3 which is at the end of residency.

was the sum of the ten questions in Section B of the survey self-assessing residents' ability to perform PALS skills (Appendix A). Confidence with 10 skills could range from 10 (minimal confidence) to 50 (maximal confidence). All residents self-assessed skill indexes improved during the education intervention ($p<0.0001$). Figure 2 shows that PGY3's were significantly more confident in their skills than PGY2's and PGY1's ($p<0.0001$).

Med/peds residents were significantly more confident than pediatric residents having lower worry indexes and higher skills indexes ($p<0.01$). The average worry index for med/peds residents was 11.9 ± 2.4 pre-mock codes versus 13.6 ± 1.7 for pediatric residents while post-mock codes the average med/peds score was 10.2 ± 3.5 versus 12.1 ± 2.2 for pediatric residents. Med/peds residents were also significantly more confident with resuscitation skills than pediatric residents ($p<0.01$) at baseline and at the end of the study period. Med/peds average skill index pre-mock codes was 33.1 ± 11.4 versus 28.0 ± 9.4 for pediatric residents. The average skill index post-mock codes was 41.6 ± 5.7 for med/peds residents and 34.7 ± 7.7 for pediatric residents.

The worry and skill indexes were compared for PGY3's who had not participated in any mock codes to PGY3's who had 1 year of mock codes. The same comparisons were also completed for PGY2's and PGY1's. Although all indexes, except PGY2's skill index, improved during mock codes, they were not statistically significant.

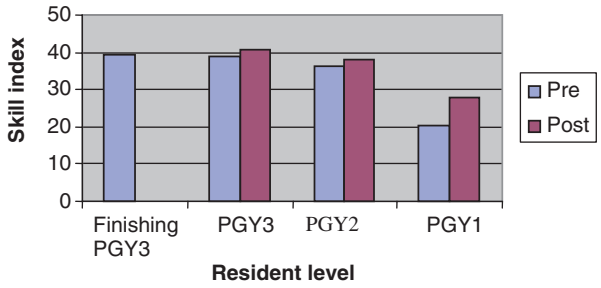

Figure 2. Skills index = ability to intubate (infants, toddlers, children, teens) + ability to 'run' code + ability to treat (respiratory arrest, seizure, cardiac dysrhythmias) + ability to perform chest compressions + ability to place interosseous (IO) line. (range 10 (low confidence) to 50 (high confidence)). MC = mock code, PGY = post graduate year. Resident level is at the start of the indicated PGY, except for finishing PGY3 which is at the end of residency.

Table 1 shows the lowest four skill scores both pre- and post-mock codes. All code skill areas improved and all were statistically significant except: I know the PALS algorithms ($p=0.17$) and ability to perform chest compressions ($p=0.06$).

Discussion

Hospital-wide mock codes can help teach and reinforce resuscitation skills. Residents felt significantly more comfortable about their resuscitation skills and were more confident at the end of the year of mock codes regardless of the level of training. These findings are similar to two studies involving internal medicine resident's perceptions about cardiac arrests (Scott et al. 2003; Hayes et al. 2007). This improved confidence is likely attributable to the experience of direct patient care as opposed to mock code participation. We found that confidence level improved as PGY increased; however, this was true for participants with and without mock code experiences.

Comparison of resident classes who participated in mock codes to the previous resident class which did not, revealed higher scores from mock codes exposure. However, these differences did not reach statistical significance. During the study period there were an average of two codes per month; however, some residents never attended a mock code. We do not know how many mock codes individual residents participated in. The code team is comprised of three residents and, although others often attend, most residents are not present. Presence on the code team is determined by on call status and rotation specific responsibilities, such as rotations in the PICU and the admitting general ward team. Also, because actual pediatric cardiopulmonary arrests are relatively rare, some pediatric residents may only lead a limited number of codes – either mock or real. This may have limited our ability to detect an education improvement. Another explanation was that the two classes of residents may have had underlying differences from the start and may not have been directly comparable. This seems less likely as each class was recruited similarly and each class was filled entirely by the match system.

Cappelle and Paul (1996) conducted the only known randomized, control trial of pediatric mock codes. They exposed 16 pediatric residents to an average of three mock codes over a period of 4 months, 17 similarly matched residents served as controls. They also found that most residents were scared about codes (79%) and felt they

Table 1. Lowest skills pre- and post-mock codes.

Ranking (pre)	Ranking (post)	Skill	Average score (pre)	Average score (post)
1	4	Ability to supervise a code	2.14	3.23
2	2	Ability to treat cardiac dysrhythmias	2.56	3.09
3	1	Ability to place interosseous line	2.57	3.00
4	3	Ability to intubate teenagers	2.67	3.11

Note: Skill range 1–5, 1 = not at all confident, 5 = strongly confident.

needed more knowledge (76%) and experience (82%) before supervising an actual code. They found that the residents who participated in mock codes had more confidence in their ability to supervise a code and were more confident in obtaining intravenous access and performing an intubation during a code. Unlike their trial, our trial did not exclude residents from the experience but also did not systematically target a subset of residents exposing them to consistent mock code experiences.

Many pediatric residents feel ill-prepared to run a code despite recent PALS training. These findings are similar to a study by Hayes et al. (2007) evaluating internal medicine residents in Canada. Their survey showed that almost half of the residents felt inadequately trained to lead cardiac arrest teams and that 51% felt that the advanced cardiac life support (ACLS) course did not provide adequate leadership skills. PALS, like ACLS for adults, is the standard of care for training pediatric providers in the skills and algorithms for treating cardiopulmonary arrests in children. But like ACLS, it focuses on minimal competency.

Individual skills self-assessment scores varied both pre- and post-mock codes. Those skills that were least often encountered during a pediatric residency; ability to supervise a code, ability to treat cardiac dysrhythmias, ability to place an IO line and ability to intubate teenagers were the lowest four in the pre-mock code survey. Surprisingly, the lowest skill set during the post-mock code survey was the ability to place an IO line. This vital skill is taught to every participant during each PALS course and is considered to be easy to perform (Blumberg et al. 2008). In a recent survey of pediatric program directors, more than 60% felt IO placement was very important (rated $\geq$8 out of 10) for pediatric residents to be competent in performing. Interestingly, just over 20% of program directors responded that 'all or almost all' of their residents were competent to perform this skill at the end of their training (Gaies et al. 2007) Despite the perceived importance, it is rarely performed by pediatric residents in our large children's hospital and is often unsuccessful either in the pre-hospital setting or the hospital. IO placement is rare in part because there are expert pediatric health care providers who are able to obtain intravenous access in almost all pediatric patients. When needed it is often unsuccessful due to many reasons including the fact that most pediatric residents have never placed a needle in a bone. The only other procedure which requires this skill is a bone marrow aspirates which is now rarely done by residents at our institution. Bone marrow aspiration is similar to the IO line placement in the technique as well as the unusual feel of a large needle coring into a bone. The feel is unique and until experienced, it is difficult to describe the amount of force necessary to place a needle into a bone. One way to simulate this 'feel' is to use chicken thigh bones. The hardness and sudden give in resistance felt as the marrow space is penetrated is very similar to an infant tibia. For infectious safety and ease of repeated classes, our PALS instructors over the past 5 years have changed from practicing IO lines on chicken bones to now practicing them on plastic mannequins. Although mannequins are cleaner they are not as realistic as chicken bones. More research is needed to determine whether this trend permeates other large pediatric teaching hospitals.

A second skill set that is unique to pediatrics is that of intubation of various sized children. Intubation is often encountered in the delivery room and neonatal intensive care unit (NICU). As such, our pediatric residents had high comfort levels with intubating infants. This differential in intubation skills of different age groups is in agreement with Gaies et al. (2007). They found that 60% of program directors rated their residents as 'all or almost all' being able to perform neonatal intubation at the completion of their pediatric training but only approximately 30% felt their residents were able to perform non-neonatal intubations at the end of their training. This is important to distinguish as other opportunities to practice on these older children, such as simulators and operating room experiences may be useful in augmenting this important skill set.

We found that med/peds residents, regardless of year of training, were statistically more confident in their attitudes about codes and about their self-assessment of their ability to perform resuscitation skills. In the course of their internal medicine training, med/peds residents are exposed to more cardiopulmonary arrests, with the most frequent etiology being cardiac. This likely relates to their improved level of confidence. Although the majority of med/peds residents felt too much time was spent in the NICU, many desired more training in the PICU (Melgar et al. 2006). The Accreditation Council of Graduate Medical Education requires 8 total months of intensive care rotations for med/peds residents with half in internal medicine and half in pediatrics (3 in NICU and 1 in PICU) (ACGME website). Further research is needed to determine if this increased confidence translates into improved abilities. However, Lum and Galletly (1989) showed that among medical officers, performance was not correlated to confidence. Also, Marteau et al. (1990) showed that experience without feedback lead to increased confidence but not increased skill.

An unexpected benefit of our mock code program was the identification of many system-based problems. The first example involved the code notification system. Our hospital uses both an overhead paging system to identify a cardiopulmonary arrest as well as individual pages code team members. The overhead paging system is also used for various other notifications such as to have parents or patients return to their rooms. This type of overhead paging significantly exceeds the number of code pages, creating a high noise to signal ratio. As overhead paging becomes background noise, code team member attention declines and is eventually tuned out. Three distinct beeps were added prior to the announcing of the code location to clearly distinguish the two types of overhead pages. A second area for improvement involved standardizing the approach to non-patient care floors codes such as radiology or dialysis. We found during our mock codes that often codes in these areas were more disorganized and often lacked important components including an appropriate monitor and an extra oxygen tank. The responder from the respiratory division now brings a 'Green bag' which contains an extra oxygen tank, pulse oximeter, and laryngoscopes to each cardiopulmonary arrest. The responder from the

Emergency department brings a 'resuscitation wagon' to all codes not located on a patient care floor. This contains a monitor and other backup equipment normally located on the code cart. Finally, we have located areas of the hospital where access is difficult such as the parking deck and have installed automatic external defibrillators.

There are several limitations to this study. Because of the composition of our code team and having only 20 mock codes over a year; residents did not participate equally in the educational experience. Also, our control group was a historical control prior to the initiation of mock codes at our institution. Although on average, most resident classes are similar we have no data to account for small yet important differences.

Conclusion

Although the mock code program helped our hospital system identify ways to improve its efficiency, its effect on individual residents was variable. This is most likely due to the limited number of educational opportunities of each mock code. Interosseous line placement was rated as the lowest post-intervention skill. This has lead us to design a mock-code experience for each second-year resident during each of their two intensive care unit rotations practicing both leading codes and IO line placements. Hopefully with more emphasis, this important skill of pediatricians can be improved. Future efforts will need to include ways to document translation of educational experiences in the clinical arena.

Declaration of interest: The authors report no conflicts of interest. The authors alone are responsible for the content and writing of this article.

Notes on Contributors

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Appendix A

Pre-Mock Code Survey

SECTION A:

Using the scale below, please rate your items 1–4 below:

SCALE:

1 = strongly disagree 2 = somewhat disagree 3 = neither agree nor disagree
4 = somewhat agree 5 = strongly agree

1. Codes scare me ……..	1	2	3	4	5
2. I need more knowledge about codes ……...	1	2	3	4	5
3. I need more experience about codes ……..	1	2	3	4	5
4. I know the PALs algorithms …….	1	2	3	4	5

SECTION B:

Using the scale below, please rate your confidence in your ability to perform the various elements of a code listed in items 1–10.

SCALE:

1 = not at all confident 2 = somewhat non-confident 3 = neither confident nor non-confident
4 = somewhat confident 5 = stongly confident

1. Ability to perform intubation in infants (0–1yo) …….	1	2	3	4	5
2. Ability to perform intubation in toddlers (1–3yo)……	1	2	3	4	5
3. Ability to perform intubation in children (3–12yo) ….	1	2	3	4	5
4. Ability to perform intubation in teens (13–18yo) ……	1	2	3	4	5
5. Ability to supervise/run a code ……..	1	2	3	4	5
6. Ability to treat respiratory arrest ……..	1	2	3	4	5
7. Ability to treat seizure ……..	1	2	3	4	5
8. Ability to treat cardiac dysrhythmias ……	1	2	3	4	5
9. Ability to perform chest compressions ……..	1	2	3	4	5
10. Ability to place an interosseous line ……	1	2	3	4	5

Unique Identifier Number: _____

Comments: (please comment on things you would like to review and emphasize during mock codes)_____

_____

_____

Appendix B

Mock Code Evaluation Sheet

Code # _____ Code Date: _____

Location: _____

Scenerio:_____

_____

Response Time (sec):

Code Button:_____Overhead Code Alert:_____Pagers:_____

Doctors: _____Pediatric Surgery: _____ X-ray: _____

Nurses: _____Transport: _____ ED Nurse:_____

Pharmacy: _____PICU nurse: _____ Pastoral Care:_____

Respiratory: _____IV Therapy:_____ Anesthesia: _____

Team Leader: _____ Designation time (sec): _____

Time to initiate (sec):	**Appropriate Use of: (yes /no/ N/A)**
Airway:	CPR Backboard:
Breathing:	CPR Technique:
Circulation:	ETT Size:
Monitor Hookup:	Laryngoscope:
Saturation Probe:	NG Tube:
IV Access:	Intubation:
Nasogastric Tube:	Chart Obtained:
Other:	PALS algorithm followed:

Appropriate Use of Medicines / procedures (yes / no / n/a):

Epinephrine: _____
Atropine: _____
Ativan (antiseizure medicine): _____
Adenosine: _____
Defibrillation: _____
Interosseous: _____
Antiarrthymia agent: _____
Other: _____

Comments: _____

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