SIMULATION TRAINING IN ENDOTRACHEAL INTUBATION IN A PEDIATRIC RESIDENCY

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Abstract

Background: Airway management and endotracheal intubation are essential skills for pediatric residents. Simulation-based technology is used for training residents but it remains unclear whether high fidelity simulation results in better retention of skills compared to low fidelity. The study assesses high fidelity simulation of endotracheal intubation and traditional low fidelity training in improving pediatric residents' knowledge retention and technical skills; and if the difference translates into higher "real time" intubation success rates.

Methods: Second and third year pediatric residents were randomized into high fidelity (intervention) or low fidelity simulation (control) groups. Airway management and intubation skills were taught using a didactic lecture and demonstration on low fidelity mannequins. Knowledge was assessed before randomization (T0) and 6 months after training (T6). Other outcome measures were: 1) airway management and intubation skills at T6 and T12 (12 months later) and 2) successful intubation of actual patients by T12.

Results: 10 out of 11 residents completed the intervention. Theoretical knowledge improved for both groups. Participants made less mistakes (M) overtime: M (T0) =3.2 and M (T6) =2.6 for the intervention group, and M (T0) =4 and M (T6) =2.40 for the control. There was no significant effect of fidelity on intubation skills or the number of successful intubations recorded in logbooks (*all p >0.05*). In some instances intubation skills showed regression over time.

Conclusion: High fidelity simulation showed no impact on residents' airway management and intubation skills. Retention of theoretical knowledge persisted over time while practical skills remained at baseline or declined.

Keywords: simulation, resident education, intubation skills, knowledge assessment.

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Introduction

Pediatric airway management is one of the most difficult skills to acquire during residency. It includes bag-mask ventilation, laryngoscope handling and endotracheal intubation skills. Most cardiac arrests in infants are respiratory in origin. Of those children who experience cardiac arrest in a clinical setting, 75% to 80% survive while those who do not receive proper intervention have a 5% chance of survival along with a heavy toll of neurological damage[1]. Airway management is therefore a life-saving and necessary skill and is an integral part of pediatric training[2]. Many factors may contribute to a deficient intubation. Inexperience or improper management of the airway can cause the patient's condition to deteriorate, not the mention the negative effect of the stressful clinical setting. The success of an intubation might therefore also require practice in a comfortable and non-threatening environment where patients are not at risk so that trainees are more confident in real-life situations.

Residents report feeling inadequately prepared when it comes to managing such stressful situations in the clinical setting. At the beginning of their residency, residents take the Pediatric Advanced Life Support (PALS) and Neonatal Resuscitation Program (NRP)[3,4,5,6]. These educational programs help with standard training. However, studies have shown that after one year, retention of knowledge and practical skills are poor[7], and airway intubation skills tend to deteriorate within a few weeks if not practiced[3]. In fact, Nadel et al[7] showed that, one year after taking PALS only 18% of residents could effectively perform and succeed at an endotracheal intubation. Other studies suggest also that PALS training is insufficient for providing residents with the adequate skills, competence and self-confidence to perform successful resuscitations[3,7,8,1].

Educational programs such as PALS and NRP offer codes of conduct according to situations but have shown to come short in building solid skills for the clinical setting. Furthermore once trained, the residents do not receive many opportunities to practice their skills due to the relative infrequency of such pediatric cardiac arrest in the clinical setting. The need for endotracheal intubation is unlikely to arise when treating children and the limited residency training hours make it difficult to acquire expertise in intubation[3,6].

In order to address this need, new educational tools based on simulation or high-fidelity training have been used to enhance airway management and intubation skills of residents. High-fidelity medical simulation replicates a clinical scenario and helps standardize the procedure for the individual practicing his or her own procedural and decision making skills within a productive anxiety level conducive for learning[1,9]. The created environment serves as an acceptable substitute for the actual clinical setting. In this environment, residents are given the opportunity to experiment through trial and error, retry, and practice without unfavorable outcomes. Simulation training permits and builds upon a process of learning derived from concrete experience[5], laying foundations for residents to practice in a supervised, standardized and patient-safe setting[10]. It allows for retention of knowledge through practice, and enhances the resident's sense of mastery, competence and efficacy[11].

Some studies show that residents who were taught Advanced Cardiac Life Support using high-fidelity simulation training performed better than their counterparts who received solely conventional training[12,13,14]. While there is some evidence that clinical skills are retained for a year after a single simulation training session[8], it is not clear whether improved skill performance during simulation translates into better performance during actual patient care.

The purpose of this study was to investigate whether training of pediatric residents using high fidelity simulation would result in retention of knowledge and improved performance during actual patient care, as compared to the traditional model of teaching at the American University of Beirut Medical Centre (AUBMC).

Methods

Study design

Pilot, randomized controlled.

Setting

Pediatric residency program at a tertiary care center, the American University of Beirut Medical Center.

This study was approved by the Institutional Review Board of the American University of Beirut and all residents signed a detailed informed consent before participating in the study.

Participants

Pediatric residents in their second and third years were recruited to take part in the study. Eleven consented of which only ten completed the study. Residents had completed the Pediatric Advanced Life support (PALS) course and the American Academy of Pediatrics Neonatal Resuscitation Program (NRP) course in their first and second year of residency respectively. Those who consented to participate were randomized to either receive traditional teaching (low fidelity assessment method) (N=5) or high fidelity simulation training and assessment (N=6) in airway management. None had participated in a high-fidelity simulation scenario involving endotracheal intubation prior to the study. Residents had diverse backgrounds, some having completed their medical studies in the same institution while others from different institutions in the same country and other Arab countries.

Inclusion/Exclusion

All residents in their second and third year were invited to participate in the study. Those who did not consent were excluded.

Process

A didactic lecture entitled "Pediatric Airway Management" was presented to all. In order to assess theoretical knowledge at baseline, all residents were given a pretest before beginning the lecture. The pretest was devised as eleven multiple-choice and true/false questions that were adapted from the official American Academy of pediatrics NRP and PALS courses. After collecting the pretest, the residents were given the lecture in addition to a demonstration of an intubation procedure performed on a low fidelity pediatric mannequin. This lecture was based on information found in "The Textbook of Pediatric Intensive Care"[15], the American Academy of Pediatrics and the American Heart Association resuscitation recommendation (Pediatric Advanced Life Support). It covered topics on airway anatomy, basic airway management, intubation technique and the equipment needed.

After completion of both pretest and lecture, informed consent forms were distributed and collected. Only pretests of those participating in the study were kept.

Intervention

The two groups were invited into the simulation lab for a first hands-on training session at T0 (beginning of study), a second training session at T3 (3 months later) and one last assessment at T6 (6 months later). The two hands-on training sessions, at T0 and T3 gave the participants ample time to deliberately practice. Both groups were exposed to one and the same environment and used the available equipment, including the same mannequin (SimBaby the advanced infant patient simulator from Laerdal and The SimBaby software Version 1.4.1 EN produced in 2007 both acquired by HSON in 2009). The mannequin was plugged into the modem and monitor for the experimental group, hence becoming a high-fidelity mannequin.

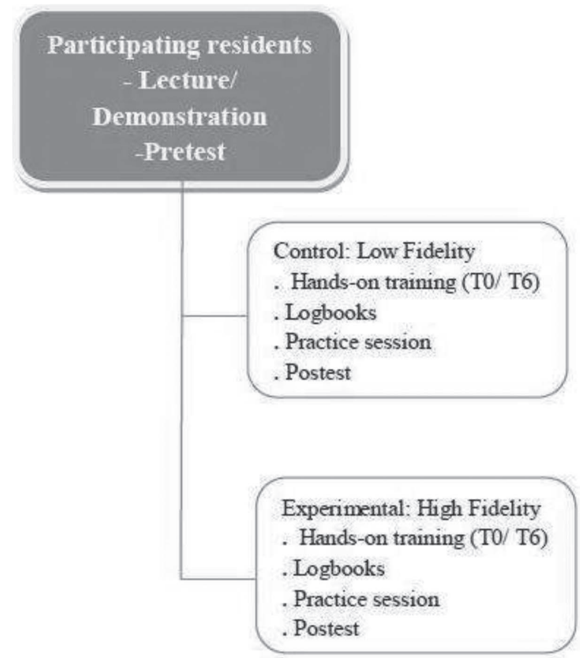
T0 session: The first session proceeded in different steps. Each participant was individually invited to the lab for a session of 30 minutes. The participant was first asked to properly cite the equipment needed for an intubation of a 6 to 8 month old infant and to then prepare the material in order to commence the procedure. The participant was allowed to practice intubations with direct feedback by a physician expert in pediatric airway management and high-fidelity medical simulation (RSC and LC). Two scenarios were then given in which a final intubation was needed. The traditional group had the vital signs and physical exam findings read out by the present supervisor, while the experimental group used the high fidelity mannequin. The scenarios were videotaped without face identification.

Logbooks were then distributed to all participating residents. Residents were asked to log in their book each intubation procedure whether successful or not. This measure served as a means to follow up on each resident to compare the intubation success rate in actual clinical settings. The logbooks would be collected 6 months later.

T3 session: A training session was scheduled 3 months later (T3). Residents were invited to the simulation laboratory to deliberately practice a minimum of 10 intubations. The control group practiced on the low fidelity mannequin while the experimental group practiced on the high-fidelity mannequin. No scenarios were given.

T6 session: The final phase of the study consisted of a final hands-on session similar to the first. Scenarios were read according to each group's assignment. The scenarios were videotaped without face identification. After completing both scenarios, supervisors debriefed participants and gave them feedback on their performance. The residents were asked to reflect on their own performance by watching it on videotape. They were given the opportunity to express their feelings and thoughts, contemplating corrective actions. A posttest was finally given to all participating residents, and the logbooks were collected (Figure 1).

Fig. 1
Randomization of participants into either high or low fidelity groups; all participating residents received a lecture and were subjected to a pretest and each group was given the same sequence in the intervention phase.



Data Collection

A pediatric anesthesiologist (R.K), blinded to the time of intervention (T0 vs T6) and to the level of training, reviewed the endotracheal intubation procedure, captured on videotape during the 2 encounters 6 months apart. Evaluation of the participants' skills in proper handling of laryngoscope, positioning of patient, use of equipment and number of attempts were all relevant criteria.

Statistical analysis

The Statistical Package for Social Sciences (SPSS) version 20 was used for the data management and analyses. Descriptive statistics was carried out by reporting the number and percent for categorical variables, whereas the mean, median, range and standard deviation were reported for continuous variables. Association between the intervention group and the different variables was assessed using non-parametric tests, mainly, Fishers's Exact test for categorical variables and the Mann Whitney test for continuous ones. A p-value of ≤0.05 was considered to indicate statistical significance.

Results

The sample consisted of seven participants in their second year of residency and four participants in their third year. Ten out of the eleven participating residents completed the project (Table 1). Theoretical knowledge was assessed at T0 and T6. There was no effect of fidelity on theoretical knowledge. Theoretical knowledge improved with time for both groups, regardless of fidelity. The average number of mistakes (M) varied for both groups: the intervention group showed M (T0) =3.2 and M (T6) =2.6 and the control group showed M (T0) =4.0 and M (T6) =2.4 (Table 2).

There was no significant effect of fidelity on

Table 1
Basic characteristics of participants in both high and low fidelity groups

		Low Fidelity N (%)	High Fidelity N (%)	P-value
Gender	Male	0 (0.0%)	3 (60.0%)	
	Female	5 (100.0%)	2 (40.0%)	0.17
Age	Mean (SD)	26.6 (0.5)	26.8 (0.4)	0.69
Med School year	2009	2 (40.0%)	0 (0.0%)	
	2010	1 (20.0%)	4 (80.0%)	
	2011	2 (40.0%)	1 (20.0%)	0.13
Med_school_location_	Foreign	2 (40.0%)	2 (40.0%)	
	Lebanon	3 (60.0%)	3 (60.0%)	1.00
Formal training	Yes	1 (20.0%)	1 (20.0%)	
	No	4 (80.0%)	4 (80.0%)	1.00
Progression_equipment	Worse	2 (40.0%)	1 (20.0%)	
	Same or better	3 (60.0%)	4 (80.0%)	1.00
Progression_positioning	Worse	1 (20.0%)	3 (60.0%)	
	Same or better	4 (80.0%)	2 (40.0%)	0.52
Progression_Ambubag	Worse	1 (20.0%)	1 (20.0%)	
	Same or better	4 (80.0%)	4 (80.0%)	1.00
Progression_laryngo	Worse	2 (40.0%)	2 (40.0%)	
	Same or better	3 (60.0%)	3 (60.0%)	1.00
Progression_Technique	Worse	1 (20.0%)	1 (20.0%)	
	Same or better	4 (80.0%)	4 (80.0%)	1.00
Progression_ETT_placement	Worse	0 (0.0%)	1 (20.0%)	
	Same or Better	5 (100.0)	4 (80.0%)	1.00
Progression_overall	Worse	1 (20.0%)	2 (40.0%)	
	Same or better	4 (80.0%)	3 (60.0%)	1.00

Table 2

Overall Assessment and Logbook Entries in both high and low fidelity groups Pretest and posttest performance, overall assessment, number of attempts at intubation at T0 and T6, total intubations and total number of successful intubations recorded in logbooks

		Low Fidelity	High Fidelity	P-value
Pretest mistakes	Mean	4.0	3.2	
	Median (range)	4.0 (3.0)	3.0 (3.0)	0.42
	SD	1.2	1.3	
Posttest mistakes	Mean	2.4	2.6	
	Median (range)	2.0 (3.0)	3.0 (4.0)	0.69
	SD	1.1	1.5	
Overall Assessment T0	Mean	1.6	1.6	
	Median (range)	1.0 (3.0)	1.0 (2.0)	0.84
	SD	1.3	0.9	
Overall Assessment T6	Mean	1.4	1.0	
	Median (range)	1.0 (1.0)	1.0 (0.0)	0.31
	SD	0.5	0.0	
Attempts T0	Mean	1.2	1.0	
	Median (range)	1.0 (1.0)	1.0 (0.0)	0.69
	SD	0.4	0.0	
Attempts T6	Mean	1.0	1.6	
	Median (range)	1.0 (0.0)	2.0 (1.0)	0.15
	SD	0.0	0.4	
Total intubations recorded in logbook	Mean	2.6	1.8	
	Median (range)	1.0 (7.0)	1.0 (5.0)	0.84
	SD	2.9	1.9	
Successful intubations in logbook	Mean	2.0	0.8	
	Median (range)	1.0 (5.0)	0.0 (3.0)	0.31
	SD	2.0	1.3	

Table 3
Evaluation of participants' performance at T0 in both high and low fidelity groups

		Low Fidelity	High Fidelity	P-value
Equipment Use T0	Mean	1.8	1.6	
	Median (range)	1.0 (3.0)	1.0 (2.0)	1.00
	SD	1.3	0.9	
Positioning T0	Mean	1.4	1.6	
	Median range	1.0 (2.0)	2.0 (1.0)	0.55
	SD	0.9	0.5	
Ambubag use T0	Mean	1.6	1.4	
	Median (range)	1.0 (3.0)	1.0 (2.0)	1.00
	SD	1.3	0.9	
Laryngoscope Handling T0	Mean	1.8	1.6	
	Median (range)	1.0 (3.0)	1.0 (2.0)	1.00
	SD	1.3	0.9	
Intubation Technique T0	Mean	1.6	1.4	
	Median (range)	1.0 (3.0)	1.0 (2.0)	1.00
	SD	1.3	0.9	
ETT Placement Confirmation T0	Mean	1.2	1.2	
	Median (range)	1.0 (1.0)	1.0 (1.0)	1.00
	SD	0.4	0.4	

Table 4
Evaluation of participants' performance at T6 in both high and low fidelity groups

		Low Fidelity	High Fidelity	P-value
Equipment Use T6	Mean	1.6	1.8	
	Median (range)	2.0 (1.0)	2.0 (1.0)	0.69
	SD	0.5	0.4	
Positioning T6	Mean	1.4	1.0	
	Median (range)	1.0 (1.0)	1.0 (0.0)	0.31
	SD	0.5	0.0	
Ambubag use T6	Mean	1.4	1.2	
	Median (range)	1.0 (1.0)	1.0 (1.0)	0.69
	SD	0.5	0.4	
Laryngoscope Handling T6	Mean	1.8	1.0	
	Median (range)	2.0 (2.0)	1.0 (0.0)	0.15
	SD	0.8	0.0	
Intubation Technique T6	Mean	1.4	1.0	
	Median (range)	1.0 (1.0)	1.0 (0.0)	0.31
	SD	0.5	0.0	
ETT Placement Confirmation T6	Mean	1.2	1.0	
	Median (range)	1.0 (1.0)	1.0 (0.0)	0.69
	SD	0.4	0.0	

practical skills. Equipment use, positioning, ambubag use, laryngoscope handling, intubation technique and ETT placement were not different (p>0.05) when comparing both groups at t(0) (Table 3) or t(6) (Table 3/4).

Successful intubations recorded in the logbook did not vary as a function of fidelity across groups (p=0.31).

Discussion

Theoretical knowledge improved as a function of time and with recurrent examination for both groups, regardless of exposure to either high or low fidelity. Practical skills did not improve for any group and even regressed in some individual cases. High fidelity simulation had no effect on theoretical or practical skills of residents. This finding shows that practical skills may need more training than theoretical knowledge.

The second aim of the study was to compare the intubation success rate in actual clinical settings of pediatric residents in the intervention group vs. the traditional teaching group during the first 6 months of the intervention. This was assessed with the help of logbooks. The results of successful intubations and the number of intubations in the logbook were not in any way correlated to participant groups. High simulation training did not therefore affect intubation success rate in the actual clinical setting.

The third aim was to contrast the effect of simulation and traditional teaching on retention of knowledge and rate of successful intubation of actual patients 6 months after completion of the intervention. Knowledge retention was indeed found to be solid at T6. Participants made fewer mistakes on the post-test questionnaire than they did on the pre-test. This was found once again regardless of fidelity, and consistent with the first hypothesis. The rate of successful intubations on actual patients after completion of the intervention did not vary as a function of fidelity.

Fidelity had therefore no significant effect on practical skills or theoretical knowledge. This finding can be due to many limitations.

Previous literature found that establishment of mock codes program during residency helped improve residents' perception in overall skills[16]. Residents who previously fired a defibrillator on a mannequin were more likely to successfully use the defibrillator in a simulated scenario[17] and simulated-based mock codes significantly correlate with improved pediatric patients cardiopulmonary arrest survival rates[3]. Consistent with the literature, practical skills need much practice and training. Even after training, feedback and multiple scenarios across a stretch of 6 months, residents still had difficulty with both the traditional and the high-fidelity training. The literature does emphasize the importance of repetitive training and the inefficiency of PALS alone to solidify knowledge and acquisition of a difficult skill like endotracheal intubation. Even though this study has endorsed more rigorous training than what residents are usually offered, it still fell short in terms of efficient training to improve practical skills. Frequent and repetitive training in intubation is therefore important for skill maintenance over time.

Limitations

A major limitation is the small sample size of the residency program. This however allowed for one-on-one training and immediate and direct feedback from the trainer. The attitude of the participants was also an issue. Some participants did not want to be tested despite consenting to the study and the videotaping. A reluctance to properly engage with the study might have affected their performance and their whole disposition towards the study. This might be due to a problem in the methodology regarding the way their performance was recorded for later assessment. The problem was not recorded in studies using similar methods[18,19] potentially highlighting cultural issues.

Conclusion

In conclusion, in a small residency program, high-fidelity and low-fidelity airway training did not affect residents' intubation technique or actual procedural success when followed over one year. Future studies should involve a higher number of participants, multi-center design, potentially across several specialties where endotracheal intubation is a required competency.

Acknowledgements

The authors would like to thank Ms. Randa Farha, the simulation lab coordinator, for setting up the mannequins and booking the lab for the study.

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