Assessment of a point-of-care information system in simulated pediatric anesthesia emergencies

H. Berkenstadt¹, ², ⁴, Y. Yusim¹, ⁴, A. Ziv², ⁴, T. Ezri³, ⁴, O. Rubin², ⁵, A. Perel¹, ⁴

¹ The Department of Anesthesiology and Intensive Care
² The Israel Center for Medical Simulation (M.S.R)
³ Sheba Medical Center, Tel Hashomer, Israel, Department of Anesthesiology, Edith Wolfson Medical Center, Holon
⁴ Sackler School of Medicine, Tel Aviv University, Israel
⁵ National Institute for Testing and Evaluation (NITE), Jerusalem, Israel

Abstract

Introduction: The use of written protocols in simulated pediatric resuscitation scenarios was associated with a significant reduction in drug administration and equipment selection errors. Recently, the value of a point of care information system in helping anesthesiology residents in the diagnosis and treatment of simulated malignant hyperthermia was demonstrated. The present study evaluated the value of using a point of care information system in the treatment of simulated pediatric anesthesia emergencies.

Methods: We evaluated the use of a point-of-care information system (OLEH, on line electronic help) during the treatment of three simulated pediatric anesthesia emergencies by anesthesia residents.

Results: The score for anaphylaxis treatment was 16.2 – 2.6 (maximal score 23) in the OLEH users group (n = 11) and 12 – 3 in the non-users group (n = 17) (p = 0.002). Epinephrine in a correct dose was given by 10/11 of the OLEH users and by 9/17 of the non-users (p < 0.035). Adenosine in a correct dose for the treatment of supraventricular tachycardia was given by all 11 OLEH users and 8/17 of the non-users (p < 0.02), and cardioversion was correctly performed for the treatment of wide complex tachycardia by all 8 OLEH users and 14/20 of the non-users (p < 0.08). The time elapsed from the beginning of the scenario to decision on adenosine dose or defibrillation energy was not different between groups.

Conclusions: The findings support the use of a cognitive aid such as the OLEH for the management of anesthesia related pediatric emergencies.

Keywords: simulation, point of care information, patient safety

Introduction

The limited ability of humans to incorporate information during decision-making [1] is in contrast to the large amount of information required by physicians in the clinical environment and to the continually growing amount of medical knowledge [2]. The aviation industry, facing similar challenges to clinical medicine, mandates the use of formal checklists to ensure that all protocols are followed rather than relying on human memory alone. In medicine, a surgical safety checklist reduced morbidity and mortality [3], and mandatory checklist of protocols and objectives improved compliance with a wide range of evidence based intensive care practices [4]. In medical emergencies, a general algorithm for crisis management in anesthesia was developed as part of the Australian Incident Monitoring Study (AIMS) [5] followed by algorithms for specific anesthesia events such as hypoxemia, laryngospasm and difficult intubation [6-8]. A point of care information system improved the diagnosis and treatment of malignant hyperthermia in full-scale simulated operating room [9, 10]. However, cognitive aid failed to improve neonatal resuscitation in a similar set up [11].
Methods

Participants: After institutional ethics committee approval and personal informed consent, 28 anesthesia residents from two anesthesia departments participated in a pediatric anesthesia, simulation-based training conducted at M.S.R – the Israel Center for Medical Simulation. Participants were 12-36 months into their 5 years residency training, following at least one-month training rotation in pediatric anesthesia, and had no clinical experience or previous simulation-based training in the scenarios presented during the training.

The point of care information system: The On-Line Electronic Help (OLEH) is a point-of-care information system for the anesthesia-provider in the operating room that was developed by the European Society of Anaesthesiologists (ESA). (OLEH demo can be downloaded [12]). The OLEH provides vital information on drugs, preoperative considerations, surgical sub-specialities, intraoperative complications, and emergency algorithms including fast-access buttons for 15 emergency scenarios. Information on pediatric drugs as well as pediatric resuscitation protocols is available. The OLEH was designed to access any item using no more than four steps. Access is further facilitated by more than 3000 internal hyperlinks for cross-referencing, as well as by separate alphabetical table of contents. As of 2003, the OLEH is available on the Philips IntelliVue monitor, and more than 5,000 copies were distributed to all ESA members for personal use.

The scenarios: Three pediatric simulation-based scenarios were developed using a pediatric human patient simulator (METI, Florida, USA).

Scenario 1: Anaphylactic reaction: A validated anesthesia related anaphylaxis scenario [13, 14] was adjusted in physiological parameters and medications dosage to pediatric anesthesia. Following anesthesia induction for an otherwise healthy eight years old boy scheduled for an inguinal hernia repair, the surgeon requested the administration of an antibiotic. At the same time, the anesthesia resident administered a muscle relaxant for surgical relaxation. An anaphylactic reaction was triggered, manifested by an increase in heart rate to 160 beats/min, a fall in systolic blood pressure to 50 mm Hg and an increase in peak inspiratory pressure to 40 cm H₂O. The participant was informed of the appearance of a rash if he or she specifically inquired. Participants were given 15 min to diagnose and treat the anaphylactic reaction and grading of the participants’ performance was focused mainly on making the correct diagnosis, and on the appropriate and timely administration of intravenous fluids and epinephrine.

Scenario 2: Supraventricular tachycardia (SVT) with stable hemodynamics: During anesthesia for an otherwise healthy eight years old boy tachycardia of 200 beats/min without hypotension developed (without any problems in ventilation or oxygenation). Grading criteria for residents’ performance included the decision to administer adenosine, the dose of adenosine, and the time from the beginning of the scenario until an order for administration of a certain dose of adenosine was given to the nurse participating in the scenario.

Scenario 3: Wide-complex tachycardia (WCT) with unstable hemodynamics: During anesthesia for an otherwise healthy eight years old boy WCT has developed, accompanied by hypotension and disappearance of the pulse oximeter pletysmographic signal. Grading criteria for the resident’s performance included the decision to use cardioversion; the amount of energy used for cardioversion; and the time interval from the beginning of the scenario until an order for cardioversion was given to the nurse participating in the scenario.

Performance assessment: The simulation training sessions were videotaped using digital video recordings. Three cameras were used (PELCO, USA), one of which was a PTZ (pan-tilt zoom) camera, connected to a digital recording system (DARIM, Korea). A four-quadrant screen was used including two separate views of the participants and the mannequin and one screen demonstrating the patients’ vital signs. Two senior anesthesiologists familiar with the OLEH system and the simulation-based scenarios reviewed the videotapes separately and independently for performance assessment. The assessment of anaphylaxis management was performed using a modified scoring system, previously validated and published (Appendix A) [11, 12], and the assessment of the SVT and WCT scenarios was based on the criteria described. The assessors documented also the timing and number of entries to the OLEH during each of the scenarios, the subjects searched, and the time spent using the system. A third observer reviewed the videotapes when a disagreement between the reviewers on action items was found or when time to task performance was different by more than 10% between them (otherwise a mean time between the measurements was performed).

Study design: Prior to the study, each participant received a 30-minute introductory session to the OLEH system, displayed on a computer screen. The participants were then randomized into two groups. In the control group, neither the OLEH nor any other source of information was available, while in the study group, the OLEH was available and its use was recommended but not mandatory. Participants were instructed that although scenarios were performed in one training session while using the same simulator, each scenario represents a new patient. Participants were also
instructed to manage the patients in the same manner as they would in the operating room, and were encouraged to verbalize their observations, possible problems and treatments administered.

Data analysis: Comparison of the performance scores in component 1 and time to completion of components 2 and 3 was performed using the Student’s t-test. The rest of the data were analyzed using χ² test for homogeneity.

Results

The two groups of participants were similar regarding gender, training time in anesthesia, and experience in pediatric anesthesia.

Scenario 1: Anaphylactic reaction: Out of the 14 participants in the OLEH group 11 did actually search the system during the scenario. The search terms used were ‘Anaphylaxis’ (7 participants), ‘Epinephrine dosage’ (4 participants), ‘Steroids dosage’ (2 participants) and ‘Bronchospasm’ (one participant). Correct diagnosis of anaphylaxis was made by all 14 participants of the OLEH group and 12 out of 14 participants of the control group (p < 0.15).

The maximal score for anaphylaxis treatment was 23. The mean score of participants who actually used the OLEH (n = 11) was 16.2 ± 2.6 while the mean score of those who did not (n = 17) was 12 ± 3.8 (p = 0.002). Epinephrine in a correct dose was given as part of the treatment by 10/11 (91%) of the OLEH users. Epinephrine was given by 14/17 (82%) of participants who did not use the OLEH (p < 0.52) but the dose was correct only in 9/17 (53%) (p < 0.035). H1 blockers were administered by 9/11 (82%) of the OLEH users but only by 8/17 (47%) of the non-OLEH users (p < 0.07). Not starting a second intravenous line (5/11), not using a pressurized infusion device (3/11) and not using the head down (Trendelenburg) position (2/11) were the most common mistakes made by OLEH users and for the non OLEH users the numbers were 8/17, 10/17 and 4/17, respectively (differences were statistically insignificant between groups).

Scenario 2: In the SVT scenario 11 participants out of 14 of the OLEH group did actually use the system during the scenario. The search-terms used were ‘Adenosine’ (8) and ‘Pediatric Tachycardia (Adequate perfusion)’ (3). All of the OLEH users decided to treat the patient with adenosine in a correct dose of 0.1 mg/kg and the time elapsed from the beginning of the scenario to decision was 98 ± 43 sec. Of the 17 non-OLEH users, 16 (94%) made the correct diagnosis, 14 (82%) decided to give adenosine (p < 0.14), 8 (47%) administered a correct dose of 0.1 mg/kg (p < 0.02), 3 (18%) administered a dose of 0.1-0.2 mg/kg and one participant (6%) administered a dose of 0.5 mg/kg. The time elapsed from the beginning of the scenario to decision making was 101 ± 48 sec (non-significant in comparison to the OLEH users).

Scenario 3: In the WCT scenario, eight participants (8/14) of the OLEH group did actually search the system during the scenario using the term ‘Pediatric Tachycardia (poor perfusion)’. These eight participants decided to treat the patient with cardioversion using 0.5-1 joules/kg and the time elapsed from the beginning of the scenario to decision was 94 ± 40 sec. All 20 participants not using the OLEH decided to treat the patient with cardioversion however, only 14 (70%) used energy level of 0.5-1 joules/kg while 6 (30%) used higher levels (p < 0.08 for comparison between groups). The time from the beginning of the scenario to actual defibrillation was 100± 54 sec (non-significant in comparison to the OLEH users).

Discussion

In this prospective, controlled study, the use of a readily accessible electronic information system (OLEH) improved the quality of treatment during simulated pediatric anesthesia emergencies. The use of the OLEH improved the adherence to treatment protocols as indicated by higher scores in the treatment of anaphylaxis, and lowered the incidence of mistakes regarding the use and dosing of epinephrine and adenosine. Such mistakes in drug administration were reported in pediatric inpatients [15], and during simulation based pediatric resuscitation scenarios [16]. Moreover, the use of written pediatric resuscitation cart based on the Broselow type (“Broselow cart”) was associated with a significant reduction in the deviation from recommended medication doses and equipment selection in simulated pediatric emergencies [17, 18]. In this study, we did not compare the OLEH to the “Broselow cart” or any other available cognitive aids.

Interestingly, the search for information in the OLEH did not prolong the time needed for therapeutic decisions (the dose of adenosine and the level of energy used for defibrillation) in comparison to the same process without using the OLEH. This finding is in contrast to previous publications stating that the lack of time is a major obstacle in using electronic information access at the point-of-care for assistance in clinical decision-making [19, 20]. The relatively fast retrieval time of information may be related to the configuration of the OLEH system. The system was designed to ensure retrieval of information within a
minimum number of steps with the search being aided by a logical design of the content and multiple internal hyperlinks.

The use of the OLEH did not lead to the maximal scoring in the anaphylaxis scenario (mean score of only 16.2 ± 2.6, max of 23). Possible explanations for this finding may include the relatively short pre-study exposure of the participants to the system, sub-optimal or incomplete presentation of the information by the system or partial understanding of the information within a stressful training environment. Although the relative weight of each of the possible explanations cannot be estimated it is clear that the scores were affected mainly by parameters that were less critical to the overall management, while the critical treatment of anaphylaxis with epinephrine was optimal for most of the OLEH users. In the context of the anaphylaxis scenario scoring, it is important to comment that although a validated simulation-based scenario and evaluation tools were used we cannot state that more points really indicate better care and outcome.

Using advanced simulation allowed us the opportunity to assess the OLEH in an environment similar to the real clinical milieu where the anesthesia provider needs to accumulate knowledge about the patient’s medical status. The routine operating room monitoring system does not enable the incorporation of all this knowledge [21], thus, challenging the multiple levels of cognitive activity required for an adequate response to critical incidents during anesthesia [22].

The results of this study are limited mainly because of the participants’ anticipation of an acute event during training coupled with their awareness that they are expected to use the point of care information system i.e. the OLEH. In a similar study in neonatal resuscitation, a significant part of the participants did not use the cognitive aid [11]. Moreover, during an acute event in the operating room, anesthesiologists may disregard or be unaware of the availability [23] of the OLEH system unless proactive training will become part of the anesthesia curriculum. Another solution may be the use of automated systems that provide essential monitoring system does not enable the incorporation of all this knowledge [21], thus, challenging the multiple levels of cognitive activity required for an adequate response to critical incidents during anesthesia [22].

Another limitation of this study is that in all three scenarios, participants were expected to manage situations that are very protocol driven. It would be interesting to review the OLEH system in situations where there is an abnormal variable but no obvious diagnosis, such as a slowly falling level of oxygen saturation.

In summary, this study demonstrates the value of using a point of care information system in anesthesia while managing pediatric anesthesia emergencies. Further assessment of the OLEH point of care information system is needed in simulation-based evaluation as well as during real operating room events.

Appendix A

Scoring System for Scenario 1: [adopted from references 9 and 10] (more then 1 point can be given to a single therapeutic intervention depending on the timing of performance)

1. Head down position (Trendelenburg)
2. Time to increase fluids administration < 12 min
3. Time to increase fluids administration < 8 min
4. Time to increase fluids administration < 5 min
5. Use pressure bag for fluids
6. Asks for second intravenous line
7. Time to administer epinephrine < 12 min
8. Time to administer epinephrine < 8 min
9. Time to administer epinephrine < 5 min
10. Initial epinephrine administered ≤ 10 μg/kg
11. 0.5 μg/kg ≤ (initial epinephrine administered) ≤ 5 μg/kg
12. 1 μg/kg ≤ (initial epinephrine administered) ≤ 2 μg/kg
13. Calls for help
14. Informs surgeon about possible anaphylaxis
15. H1 blocker
16. H2 blocker
17. Uses appropriate inhaler
18. Uses inhaler circuit adaptor correctly
19. Steroids

References

Evaluarea sistemului informatic point-of-care în urgențele anestezice pediatrică simulație

Rezumat

Introducere. Utilizarea unor protocoale scrise pentru scenariile unei resuscitări pediatrică simulație a fost însoțită de o reducere semnificativă în administrarea medicamentelor și a erorilor în selectarea echipamentului. Recent, valoarea unui sistem informatic point-of-care în scopul ajutorării rezidenților în anesteziolgie a fost demonstrată pentru realizarea diagnosticului și tratamentului în ipertermia malignantă simulație. Studiul de față evaluatează valoarea utilizării unui astfel de sistem informatic pentru tratamentul urgențelor anestezice din pediatrie.

Metoda. Am evaluat utilizarea unui sistem informatic point-of-care (OLEH, on-line electronic help) de către rezidenți în anestezie în cursul tratamentului unui număr de 3 urgențe anestezice pediatrică simulație.

Rezultate. Scopul pentru tratamentul anafilaxiei a fost 16,2 ± 2,6 (scor maxim 23) la utilizatorii OLEH (n = 11) și 12 ± 3 în grupul non-utilizatorilor (n = 17) (p = 0,002). Adrenalină în doză corectă a fost administrată la 10/11 utilizatori OLEH și 9/17 non-utilizatori (p < 0,035). Adenozina pentru tratamentul tachicardiei supraventriculare a fost administrată în doză corectă la toți cei 11 utilizatori OLEH și 8/17 din non-utilizatori (p < 0,02), iar cardioversia pentru tratamentul tachicardiei cu complexe largi a fost efectuată corect de toți cei 8 utilizatori OLEH și 4/20 dintre non-utilizatori (p < 0,08). Timpul scurs între începutul scenariului până la decizia privind doza de adenozină sau cantitatea de energie pentru defibrilare nu a diferit între cele două grupuri.

Concluzii. Rezultatele susțin utilizarea unui suport cognitiv precum OLEH pentru managementul urgențelor din anestezia pediatrică.