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The role of pulsoximetry simulator during paramedic student pediatric resuscitation examination

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One of the most important aspects of advanced life support training is proper simulation. Our work group has built a pulsoximetry simulator, which can assist our students' decisions. Paramedic students' patient assessment tasks were explored during pediatric resuscitation examinations. The main question was how the pulsoximetry simulator can affect our students' patient assessment procedures in a simulated pediatric resuscitation situation. Cross section survey was conducted among 87 bachelor paramedic students. Patient assessment tasks were investigated during their resuscitation examination with checklists. The students were divided into two groups. The first group was offered a pulsoximetry simulator for the scenario. The other part of students had only verbal information about oxygen saturation and peripheral pulse. More students of those who had pulsoximetry simulator examined airway (p=0.046) and measured oxygen saturation (p=0.002) compared to those who had to ask the facilitator for information on oxygen saturation. In conclusion, pulsoximetry simulator can affect students' performance in patient assessment during simulated pediatric resuscitation situation.

Keywords: education; patient outcome assessment; oximetry; resuscitation; patient simulation

INTRODUCTION

Patient simulation as educational method is important part of any healthcare education. Simulation-based education is now widespread not only in medical education, but it is also effective in nursing educational programs (1, 2). In a simulated medical environment, students can learn how they can detect, prevent and rectify their errors. There are many advantages of simulation training over traditional medical education: safe environment, detailed planning, objective assessment, evaluation and feedback, ability of repeat scenarios, and opportunity for team learning. The major part of current health care students have grown up with digital technology and expect the use of technology in the delivery of courses, but the list of literature on this issue is very short (3).

In 1956, *Benjamin Bloom* defined three types of learning: cognitive way (determined by mental skills), affective way (feelings and attitudes), and psychomotor way (manual skills). Successful solution of a simulated emergency medical situation needs cognitive skill (knowledge), adequate behavior (affective level of learning), and sufficient manual and communication skills. Cognitive level includes acquisition and recall of facts, but psychomotor and affective domains are also important to students and trainers (4).

Problem-based learning represents pedagogical basis for simulation, which is also promoted by the European Resuscitation Council (ERC). In 2010, ERC declared that simulation training is an essential part of resuscitation training (5, 6). From another perspective, patients expect high quality service and safety, especially in emergency medicine (7). Skill acquisition is necessary for every health care provider, but in real circumstances, patient safety and many ethical

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issues might be compromised. Because of ethical problems it is less possible to practice invasive or any other harmful interventions (e.g., injections, catheter insertions, etc.) or even complex scenarios on real patients (8).

Strategies to improve students' performances during ALS trainings should be investigated and potentially may result in improvements in clinical practice. Future developments need to look at improving the performances of the skills rather than concentrating on the contents of the guidelines (9). Simulated situations have to be realistic as far as possible. More realistic components lead to more realistic complex scenario. These components are the patient himself (who or what performs the patient), symptoms and complaints, circumstances of the scene, and available diagnostic and therapeutic tools. As we support our students to be able to imagine an emergency situation with realistic scenario, they can solve more properly the real emergency situations (10).

Simulation also assists the evaluation process during practices and examinations because scenarios could be standardized, which can help objectivity and comparison. Modern medical simulators offer a wide range of procedures, which can be carried out on the manikin but also support medical decision making with signs (11). The level of fidelity could be different, but first of all it depends on financial circumstances. High fidelity human patient simulators are costly.

The aim of an educational organization must be to find a useful, appropriate and affordable tool. Nurse educators must develop realistic learning experiences that support student transition to the clinical setting. There is also a need among health care educators to expand the literature on simulation as an educational method (12, 13).

Essential elements, accentuated by international guidelines, must be very realistic in simulated ALS situation. One of those factors is to visualize pulsoximetry.

Pulsoximetry is a standard method to measure peripheral arterial oxygen saturation and pulse. Some experts say that oxygen saturation is the fifth vital sign after pulse, blood pressure, temperature and respiratory rate in acute pediatric assessment. The base of pulsoximetry is the spectrophotometry, which refers to the Beer Lambert law: light absorption depends on the material and the distance. The instrument, placed on a translucent part of the patient's body (earlobe, fingertip), is measuring absorbed red and infrared lights. It has different rates by oxygenated hemoglobin compared with deoxygenated hemoglobin (14).

There are existing methods for simulating pulsoximetry, but all of them have their limitations, for example, their cost (15). At University of Pécs, Faculty of Health Sciences, Department of Emergency Care, a pulsoximetry simulator has been developed and implemented in order to support our students' learning and decision making process.

In case of an emergency, fast and appropriate patient assessment is the basis of professional life saving interventions. In case of emergency situation, the ABCDE approach in patient assessment consists of the following: "A" as airway, "B" as breathing, "C" as circulation, "D" as disability and "E" as exposure. Every element of this approach must be part of the critical patient assessment. This is applicable to both adults and children.

There are four elements of "B" as an assessment factor: frequencies of respiration, respiratory work, respiratory volume and oxygen saturation. We can simulate every ABC parameter, but simulation of oxygen saturation is only limited. If in a simulation based scenario, continuous oxygen saturation (and peripheral pulse) is not available, students need to ask about it and instructor must inform them verbally. Consequently, this method cannot be so realistic and does not support decision making of a student as a team leader.

One of the most important factors is the prospective benefit of increased competence and safe practice of practitioners according to simulation. Although there is some ambivalence regarding the realism (fidelity) of the simulator and the case scenarios, the simulated learning is considered to be an authentic learning experience (16, 17).

In summary, the ABC approach to patient assessment and its role in education are of great significance across the globe, as high quality emergency care can only be provided in the manner intended.

Our work group has created a pulsoximetry simulator, which can effectively help in our students' decisions. It looks like a real pulsoximetry device. There are two primary displays: one for oxygen saturation (%) and one for peripheral pulse (rate/minute). The instructor can set both primary displays from his second display, with switches (Figure 1).

FIGURE 1. Pulsoximetry simulator used in a scenario with LIFEPAK 12 defibrillator

The purpose of the cross-sectional correlational study was to explore the role of our pulsoximetry simulator. The main question of our study was: Do those who have an opportunity to use pulsoximetry simulator perform better than those who have only verbal information on it?

METHODS

A descriptive, cross-sectional study design was used to investigate how pulsoximetry simulator affects patient assessment performances in a simulated pediatric ALS (PALS) situation. Our group decided for pediatric scenarios due to two major reasons: the ABC approach in patient assessment is required for prehospital caregivers, but especially in pediatric cases, when paramedics have to assume airway and/or breathing problems. In addition, there are much more scientific publications on this topic related to adults than to children (18).

The participants were fully informed about the purpose of the study and they agreed to participate. Altogether 87 undergraduate paramedic students of paramedic BSc program at University of Pécs, Faculty of Health Sciences, Department of Emergency Care were involved in this study on a voluntary basis. All students were in their final year of the program. Anonymity of the simulation results was guaranteed.

Our survey was equivalent with our students' major high-stakes testing (19) in PALS as part of their final examination.

The performances were measured using checklists developed by the researchers. Our checklist was developed especially for pediatric scenarios and consisted of two subcategories: assessment (history and physical examination) and immediate actions. These checklists outlined the essential actions which paramedic students might reasonably be expected to perform. The content validity of the checklists was established by a panel of emergency medical instructors and refined after testing with a smaller group of students. A weighting system was used to score checklist items: 0 point for no attempt or unsuccessful attempt and 1 point for a successful attempt (Figure 2).

			POINTS	
FIRST ASSESSMENT	A	Airway	1	assessment procedure accepted: 1
	B	Breathing frequency	1	
		Breathing volume	1	
		Oxygen saturation	1	
		Work of breathing	1	
	C	Frequency of peripheral pulse	1	
		Fullness of pulse	1	
		Blood pressure	1	
		Assessment of preload	1	
		Measuring of capillary refill time	1	
SECOND ASSESSMENT	A	Airway	1	assessment procedure accepted: 1
	B	Breathing frequency	1	
		Breathing volume	1	
		Oxygen saturation	1	
		Work of breathing	1	
	C	Frequency of peripheral pulse	1	
		Fullness of pulse	1	
		Blood pressure	1	
		Assessment of preload	1	
		Measuring of capillary refill time	1	
			20	2
			22	

FIGURE 2. **Checklist for scoring**

For patient simulation, the Leardal Megacode Kid was used, with VitalSim owned by the Skill Lab of the Faculty of Health Sciences, University of Pécs.

Students had to perform PALS procedure as team leaders. Participants worked with two other rescuers. Each participant worked with the same team. Completely standardized pediatric scenarios were built up out of the hospital emergency scenario. The focus was on the "A", "B" and "C".

In this standard situation, teams found six-year-old children alive and responsive, but in serious life-threatening condition. Consequently, each of them needed quick and professional ABC approach assessment. In addition, after two minutes, children needed further ABC assessment according to changes in their breathing condition. Forty-four percent of the students used pulsoximetry simulator and the other 56% of them had to ask about the level of oxygen saturation and peripheral pulse verbally from the instructor. We scored each element of the ABC based patient assessment separately on the initial and repeat (second) assessment.

For data processing, the chi-square, Mann-Whitney, Spearman's correlation tests and linear regression with MS Excel 2007 and SPSS for Windows 17.0 software were used.

RESULTS

Sample

The study included 87 paramedic students, 50 male and 37 female. The youngest participant was aged 22 and the oldest 50, mean age 30.9 years. All participants were graduate students and the majority of them studied in full time program.

Differences and correlations related to students' performances

On the measurement tool used, the maximum attainable score was 22 points (11 for initial assessment and 11 for repeat assessment). The mean students' score was 6.1 points on their initial pediatric assessment and 5.3 points on repeat assessment.

Gender differences

There were some significant gender differences in students' performances. On the initial assessment of the given scenarios, 25 (50%) male and 29 (78.5%) female students examined patient breathing volume (p=0.007), 14 (28%) male and 19 (51.4%) female students assessed work of breathing (p=0.026), and 11 (22%) male and 19 (51.4%) female students measured capillary refill time (p=0.004) (Table 1).

TABLE 1. Gender differences during first assessment

Gender	Task	YES; performed	NO; not performed	n	p
Men	Volume of breathing	25 50%	25 50%	50	0.007
Women		29 78%	8 22%	37	
Men	Work of breathing	14 28%	36 72%	50	0.026
Women		19 51%	18 49%	37	
Men	Capillary refill time	14 28%	36 72%	50	0.004
Women		19 51%	18 49%	37	

Male students achieved a mean of 5.5 points, while female students achieved a mean of 7.08 points out of the maximum of 11 points of the pediatric scenario first assessment (p=0.011).

Differences based on participant age

During their first assessment, the mean age of the participants who measured oxygen saturation was 29.2 years, while the mean age of those that did not do it was 32.6 years (p=0.016). The mean age was 28.4 years in the participants that examined work of breathing and 31.9 years in those that neglected this important duty (p=0.021). The mean age of students that measured capillary refill time was 26.6 years, while the mean age of those that skipped this task was 32.6 years (p<0.001).

On repeat assessment, the mean age was 28.4 years in students that cared about work of breathing and 32 years in those that forgot it (p=0.011). In the participants that measured blood pressure, the mean age was 28.8 years, while in those that did not it was 33.8 years (p=0.003). In those that measured capillary refill time, the mean age was 26.9 years and in those that neglected this task it was 31.3 years (p=0.023).

There was a significant correlation between age and first assessment points (p<0.001), as well as between age and second assessment points (p=0.015).

Differences based on the way of gathering information on oxygen saturation

We found no differences regarding the way of pulsoximetry on initial assessment, whereas on repeat assessment the following differences were recorded: 27 (69%) students with pulsoximetry simulator available examined airway *versus* 23 (47.9%) of those that had to ask the facilitator about it (p=0.046). Twenty-five (64.1%) students that had pulsoximetry simulator available measured oxygen saturation *versus* 15 (31.3%) of those that had to ask the facilitator about it (p=0.026) (Table 2).

TABLE 2. Differences according to pulsoximetry simulator usage

Pulsoximetry simulator used	Task	YES; performed	NO; not performed	n	p
Yes	Airway assessment	27 69%	12 31%	39	0.046
No		23 48%	25 52%	48	
Yes	Caring about oxygen saturation	25 64%	14 36%	39	0.026
No		15 31%	33 69%	48	

The ERC guideline pays more attention to the correct management of maintaining open airway ("A") and breathing ("B"). Our results highlight the differences in these steps of guideline as the core points of our study.

Linear regression

On repeat assessment, gender (p=0.011; B=1.8) and the way of pulsoximetry (p=0.005; B=1.4) determined whether or not they measured oxygen saturation. After these results, we tested genders separately: in females, age (p=0.92) and way of pulsoximetry (p=0.14) had no influence on performing oxygen saturation measurement on repeat assessment. In males, age (p=0.2) and type of education (p=0.76) did not influence repeat oxygen saturation measuring, but there was significant correlation with the way of pulsoximetry (p=0.018).

DISCUSSION

Stabilization of a child in critical condition depends on decisions of health care providers. This needs an appropriate patient assessment. Being appropriate means systematic thinking and consistent following the professional rules and guidelines. This is not easy to train. Our work group created a new tool called pulsoximetry simulator to support our students' decision making, which helps them learn and practice the ABC approach in the patient assessment procedure. Using this instrument, students can have continuous information on peripheral pulse and oxygen saturation, but without it, they have to ask the facilitator for these parameters several times during a scenario.

In this study, we investigated how the pulsoximetry simulator can support students' patient assessment performances in a simulated, standardized, adult and pediatric life support examination.

There are many differences among students' performances according to gender, age and way of pulsoximetry (pulsoximetry simulator used/verbal solution). On first assessment of situations, females assessed breathing volume (p=0.007), work of breathing (p=0.026) and capillary refill time (p= 0.004) more frequently than males. It means that women had better performance compared to men. They paid more attention to children than male participants did. This kind of gender differences may be due to emotional reasons. It is unlikely that men and women in the same study group have different cognitive abilities. Much more likely is that women subconsciously pay more attention to the injured child, thus they are more focused on the child care.

Those who had an opportunity to use pulsoximetry simulator examined airway (p=0.053) and measured oxygen saturation (p=0.002), assessed preload (p=0.046), and measured capillary refill time (p=0.026) more frequently than those who had to ask verbally for oxygen saturation level.

Differences according to age showed younger students to perform better in PALS simulation. They paid more attention to the ABC approach on assessment and neglected components from our checklist less frequently.

On repeat assessment, students who used our simulator had better performance. They examined airway and measured oxygen saturation more frequently.

Pulsoximetry simulator clearly supported students' decision-making in PALS scenarios. Inasmuch as in PALS the ABC approach has great importance, our pulsoximetry simulator needs further improvements with other simulation systems.

It is clear that our realistic pulsoximetry simulator supports decision-making and ABC approach patient assessment. Just like in reality, the pulsoximetry device mainly helps answer the question, whether the patient is alive or not, as he has peripheral circulation or not. Without this instrument, students will be uncertain, they change the steps of patient assessment, and change priorities in their decision-making process.

Our study showed that paramedic students can manage advanced life support situations, but a relatively small device can influence their performances. The study also showed deficiencies in their performances in patient assessment.

Simulation based education is a core element of advanced life support training. There are many possibilities to ensure high fidelity clinical environment but the simulation of out of hospital situations needs improvement.

CONCLUSIONS

Our simulator has many advantages: students have not only verbal, but also continuous information on the level of oxygen saturation; it is also applicable in case of a real person acting as the patient; it does not need complicated technological solutions; it is low-priced and portable.

The ABC approach patient assessment is particularly important in pediatric emergency care. We have to make an effort to set correct prehospital scenarios and support our students to make correct decisions.

Simulator environments do not necessarily reflect real world situations, and some people under observation fail to behave naturally. Repetitive exposure to the simulator may influence performance (20). It was the first attempt to simulate oxygen saturation by pulsoximetry during different advanced life support scenarios, hence retesting of the simulator might be necessary to ensure reliability and validity.

This is the first survey to examine this issue in Hungary, and in the international literature there are only few reports on the topic, especially involving children.

Despite this fact, our findings should be interpreted within the context of some limitations. Our study had a cross-sectional design that relies on self-reported data and it is difficult to support empirically the theoretically expected causal relations. Although an extensive literature search was conducted, there is a possibility that some relevant literature was omitted. The sample was relatively small and the conditions of Hungarian health care education might be different from other countries.

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SAŽETAK

Uloga pulsoksimetrijskog simulatora u ispitu paramedicinskih studenata iz pedijatrijske reanimacije

József Marton, Orsolya Máté, Emese Pék, Gábor Nagy, Krisztina Deutsch, Balázs Radnai, József Betlehem

Ispravna simulacija jedan je od najvažnijih aspekata napredne potpore za održavanje života. Naša radna skupina izradila je pulsoksimetrijski simulator koji pomaže našim studentima u donošenju odluka. Zadaci procjene bolesnika postavljeni pred paramedicinske studente ispitivani su za vrijeme ispita iz pedijatrijske reanimacije. Glavno pitanje bilo je kako pulsoksimetrijski simulator utječe na postupke naših studenata u procjeni bolesnika u simuliranoj situaciji pedijatrijske reanimacije. Ovo poprečno ispitivanje provedeno je među 87 paramedicinskih prvostupnika. Zadaci kod procjene bolesnika ispitivani su za vrijeme ispita iz reanimacije pomoću kontrolnih lista. Studenti su podijeljeni u dvije skupine. Jedna skupina imala je za ispitnu situaciju na raspolaganju pulsoksimetrijski simulator, dok je druga skupina studenata mogla dobiti samo usmene podatke o zasićenju kisikom i perifernom pulsu. Dišne putove pregledalo je (p=0,046) i periferni puls izmjerilo (p=0,002) više studenata koji su imali na raspolaganju pulsoksimetrijski simulator u usporedbi s onima koji su ove podatke morali zatražiti od asistenta. Zaključuje se kako pulsoksimetrijski simulator može utjecati na uspjeh studenata u procjeni bolesnika tijekom simulirane situacije pedijatrijske reanimacije.

Ključne riječi: edukacija; procjena ishoda bolesnika; oksimetrija; reanimacija; simulacija bolesnika