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The analysis of common errors among medical students according to Paediatric ERC Guidelines of 2000, 2005 and 2010**Małgorzata Grześkowiak**

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**Summary**

Background and objective. The knowledge to perform CPR in paediatric group should be taught to medical students and other healthcare providers. By doing so they would be able to perform CPR effectively in this group compared to the adults. The aim of this study was: (1) to analyse the effectiveness of teaching paediatric resuscitation of medical faculty students, (2) to check if any factors could influence the process of teaching and (3) to find any correlation between the possessed knowledge of adult's and paediatric resuscitation. **Material and methods.** The research was undertaken in 2003-2004 on a representative group of 400 medical faculty students (from the first/second and sixth years) recruited from four universities of medical sciences in Poland. Students' knowledge on resuscitation was assessed by a written test, which comprised of free response questions. The questions checked the paediatric as well as adult cardiopulmonary resuscitation (CPR) knowledge at basic and advanced levels. The answers were analysed based on the European Resuscitation Council Guidelines of 2000 as well as 2005 and 2010. For the statistical analysis the Kruskal-Wallis test was used. **Results.** The effectiveness of teaching of the tested groups was different (from minimum 0% up to maximum 100%). The results demonstrated a lack in knowledge in paediatric CPR in both groups. **Conclusions.** There is a need to improve the curriculum of basic and advanced paediatric resuscitation at the universities. All the universities should be equipped with paediatric manikins, so that medical students would be able to acquire the skills in paediatric resuscitation. All the teachers who teach paediatric CPR to medical students should attend mandatory courses in this field to be familiar with the latest changes in the guidelines. *Anestezjologia i Ratownictwo 2011; 5: 23-31*

Keywords: *European Resuscitation Council (ERC) Guidelines, Basic Life Support (BLS), Advanced Life Support (ALS), cardiopulmonary resuscitation (CPR), paediatric resuscitation, effectiveness of teaching, medical students, manikin study*

Introduction

Children, just like adults, could become victims needing cardiopulmonary resuscitation (CPR). The knowledge to perform CPR in this group should be taught to medical students and other healthcare providers including the paramedics and lay rescuers. By doing so they would be able to perform CPR effectively in infants and children as compared to the adults. The

curriculum of CPR differs among Universities [1-3] and the methodology of teaching itself is not the same around the world [4-6]. New teaching strategies and programs are now used to achieve better effectiveness in teaching CPR [7-10]. The ability of the performance of paediatric resuscitation is worse comparing with adult resuscitation even among the group of physicians [11-13].

The aim of this study was: (1) to analyse the effecti-

veness of teaching paediatric resuscitation on a group of first/second and sixth year medical students from four different universities of medical sciences in Poland, (2) to check if any factors could influence the process of teaching and (3) to find any correlation between the possessed knowledge of adult's and paediatric resuscitation.

Material and methods

The research was undertaken during two years in 2003-2004 on a representative group of 400 medical faculty students recruited from four universities of medical sciences in Poland. The students agreed to be tested. The idea of this study was to assess all students participating in first aid classes at the university for the first time, so 150 first year students from three universities were chosen and 50 second year students from one university where first aid course was conducted at the second year of the study. These groups of students were compared with 200 sixth year students recruited from the same four universities. The curriculum of teaching CPR at these universities was not the same and is presented in Table 1.

The curriculum contained the same objectives, but the way it's taught and perceived was different. There were neither the same teachers nor students, the didactic materials and manikins were also not the same. For this reason the comparison of these universities could be correlated to the possessed knowledge of these students. This allowed to analyse the methodology of teaching, by looking for the variables, which influence it positively and negatively.

Students' knowledge in paediatric resuscitation were analysed by a written test constructed as "free response" one. The participants had to answer to the questions, which had no multiple choices (MCQ). This kind of test with "free response" questions was

constructed because it allowed to analyse the student's real, possessed knowledge without giving them any help, as in the MCQ format. The test questions were based on the European Resuscitation Council (ERC) Guidelines of 2000 which were the current guidelines at the time of the study [14,15]. As the Guidelines of 2005 [16] and now 2010 [17] were published, they were used additionally for better interpretation of the answers given by the students. This way while reviewing the answers, I could use two viewpoints, from the past and present. The Guidelines of 2005 and 2010 [16,17] allowed to interpret common mistakes made by the students in a new way. The questions checked the paediatric CPR knowledge at basic and advanced levels. The students were asked in the test at basic level: what is the definition of the child and infant (by giving the borders of age), how to assess consciousness, what is the rule to call for help, how to open the airway, how to perform chest compressions, what is the number of the cycles when one rescuer is providing resuscitation, what are the indications to start chest compressions, how to perform artificial ventilation when circulation is present. The students were asked at advanced level: what are the ways of drug administration during resuscitation, what is a first line drug and its dose in resuscitation, what is the energy used for defibrillation, what are the potential reversible causes of cardiac arrest. The students had to write also the answers for the same questions concerning adult CPR. For correct answers, the students received the same number of points for each question.

When analysing the results, formula of the effectiveness of teaching was used. This divides the received number of points to the maximum number of points in the written test and is showed in percentage. The statistical analysis was performed using specific software (StatSoft, Inc. 2005 Statistica, version 7.1.) and Kruskal-Wallis test was used. If it's statistically significant

Table 1. The curriculum of the resuscitation at the four Universities

The year of the study	First University 1U	Second University 2U	Third University 3U	Fourth University 4U
1 st year	BR	BR	----	BR
2 nd year	----	----	BR	BR
3 rd year	BR	----	----	BR
4 th year	AR	AR	AR	AR
5 th year	----	AR	----	AR
6 th year	AR	AR	AR	AR

BR – basic resuscitation, AR – advanced resuscitation

($p < 0.05$), it means that some factors (variables) could have influenced the method of teaching. If there is no statistical significance ($p > 0.05$), none of the factors could have influenced this process.

Results

1. To analyse the effectiveness of teaching paediatric resuscitation on a group of first/second and sixth year medical students.

The effectiveness of teaching formula was used to calculate the results of the written test. This formula divides the received number of points in each question into the maximum number of points in the same question and shows it in percentage. Each question was given the same number of points. The different universities were marked as: the first university as 1U, the second as 2U, the third as 3U and the fourth as 4U.

The effectiveness of teaching (EFT) of the tested groups was different (from minimum 0% up to maximum 100%). Statistical significance ($p < 0.05$) was found eight times comparing both first (plus second year) and sixth year students. The results are presented in Table 2.

The worst results (EFT 2-54%) that statistically correlated were given by the first year students from 4U for the seven questions among eight at basic level. First year students had many problems to: "how to check consciousness" in infant (EFT 6% at 2U and 3U), "how to open the airway" in infant (EFT 30% at 2U, 13% at 3U), "what is the number of breaths/min while circulation is present" in child and infant (EFT 10% and 18% at 2U and 16%, 28% at 3U respectively).

The worst results (EFT 13-40%) that statistically correlated were given by the six year students from 4U for the six questions among eight at basic level. Sixth year students from the other universities had a lot of problems to give a correct answers to the questions: "how to check consciousness" in infant (EFT 0% at 2U and 12% at 3U), "what is the number of breaths/min while circulation is present" in infant (EFT 36% at 2U) and in child (EFT 28% at 3U respectively).

The effectiveness of teaching at advanced level varied between 24% to maximum 100%. The statistical significance was found for the questions "what is a first line drug and its dose in resuscitation" and "the potential reversible causes of cardiac arrest". The worst results (EFT 24%) presented sixth year students

from the 2U.

2. To check if any factors could influence the process of teaching.

Based on the different curriculum of the resuscitation at the four universities it could be concluded that the best effectiveness of teaching could be found at 4U (where the students attended basic and advanced resuscitation classes continuously at each year of study). Unfortunately, these students from 4U presented the lowest effectiveness of teaching comparing with the other students from three universities.

3. To find any correlation between the possessed knowledge of adult's and paediatric resuscitation.

The effectiveness of teaching adult CPR was better comparing to paediatric CPR among tested groups at basic and advanced level. Only in a few questions the opposite tendency was observed: "the definition of the child and infant" (EFT 98% versus 100% at 2U) and "what is a rule to call for help" (EFT 77% versus 83-85% at 1U and 64% versus 67% in infant at 3U). The results are presented in Table 2.

Discussion

The results of the effectiveness of teaching formula and the found statistical correlation indicated that the possessed knowledge in paediatric resuscitation is not the same among the students from the tested four universities. Some universities gave more importance to paediatric resuscitation whereas some did not. Comparing the knowledge of basic and advanced paediatric resuscitation, sixth year students knew advanced resuscitation better than the basic resuscitation.

The effectiveness of teaching basic and advanced paediatric resuscitation when compared with adults was unsatisfactory. Students' knowledge and skills in paediatric CPR, stands in contrast to adult's resuscitation, which was far better. Similar problem with graduating doctors having insufficient knowledge in paediatric CPR was found in other countries [11,19]. Studies have shown that medical students, doctors and paramedics forget the knowledge and skills of CPR, one year after graduation or attendance to the resuscitation courses [12,13,20-22].

The results showed that the best effectiveness of teaching paediatric resuscitation was found for the

Table 2. The effectiveness of teaching

Question	The effectiveness of teaching (%) – Adult (A), Child (C), Infant (I), on the first years, on the sixth year (showed in <i>italics</i>)												Statistical correlation
	First University 1U			Second University 2U			Third University 3U			Fourth University 4U			
	A	C	I	A	C	I	A	C	I	A	C	I	
The definition of the child and infant	100 94	100 88	100 96	98 96	100 92	100 94	62 82	56 86	72 96	26 60	32 58	54 86	p < 0,05 p > 0,05
How to check consciousness	90 78	90 74	96 92	78 76	70 70	6 0	74 90	46 58	6 12	74 76	42 56	2 14	p > 0,05 p > 0,05
What is a rule to call for help	77 48	83 43	85 48	54 77	53 75	49 75	64 80	44 65	67 66	32 28	27 35	34 33	p < 0,05 p < 0,05
How to open the airway	76 73	65 56	59 62	96 95	56 47	30 44	41 78	20 43	13 38	67 84	27 40	15 13	p < 0,05 p > 0,05
How to perform chest compressions	94 76	90 80	97 69	85 80	56 59	75 66	89 83	35 48	62 70	75 55	36 28	33 59	p < 0,05 p > 0,05
What is the number of the cycles with one rescuer	100 98	100 66	100 92	98 98	86 84	76 72	100 96	60 62	86 88	96 98	9 84	36 38	p > 0,05 p > 0,05
What are the indications to begin chest compressions	98 100	49 51	49 66	100 94	55 54	68 78	98 100	53 45	69 63	96 92	43 48	42 51	p > 0,05 p > 0,05
What is a number of breath/min while circulation is present	94 74	90 46	92 76	94 94	10 66	18 36	62 58	16 28	28 68	58 76	16 52	20 22	p < 0,05 p > 0,05
What are the potential reversible causes of cardiac arrest	44	44	44	80	80	80	24	24	24	46	46	46	p < 0,05
What are the ways of drug administration during resuscitation	95	95	95	99	99	99	84	84	84	100	100	100	p > 0,05
What is a first line drug and it's dose in resuscitation	100	91	91	99	84	84	95	92	92	98	79	79	p < 0,05
What is the energy used for defibrillation	94	64	64	100	76	76	92	66	66	84	58	58	p > 0,05

1U and the worst for 4U. The curriculum at four universities contained the same objectives, but the way it's taught and perceived was different. Comparing the curriculum at these universities, CPR classes were incorporated into each curriculum year of their studies at 4U and only four times at 1U. The conclusion is that this frequent teaching (each year) has not influenced the effectiveness of teaching positively. The way how the curriculum was taught and perceived rather than increased frequency of attendance to CPR classes could improve the effectiveness of teaching. The paediatric CPR was well taught at 1U. The department at 1U was well equipped with paediatric manikins and the students could practise on them. At this university the teachers were aware of the new guidelines since their knowledge was reviewed frequently. The curriculum at some universities gave more importance to adult's resuscitation than for paediatric one. At some universities paediatric resuscitation was taught only during the first year of study and later the main emphasis was put on advanced resuscitation of the adult. Few other studies has shown similar tendency [1]. It can be correlated with the decrease in the effectiveness of teaching observed at some universities for the sixth year students. This group of student during their process of study forgot basic CPR and during their sixth year, neither teachers nor students reviewed paediatric resuscitation. Sixth year students had a great increase in knowledge about the borders in age for the infant, as it's not difficult, being a sixth year student to give the correct definition of an infant. This definition of infants is the same as the definition used at paediatric classes, so it's the paediatricians who taught the students this knowledge rather than the emergency doctors or anaesthesiologists.

The analysis of the common mistakes performed by the tested students according to the Guidelines 2000 as well as 2005 and 2010

The common mistakes made in the questions based on the Guidelines of 2000, are presented below. The Guidelines of 2005 and 2010 were used additionally for better understanding of the answers.

- **Giving the definition of child and infant (the borders of age).** The students were confused about the borders of age. For a child they increased the higher border to 10-12 years of age and for an adult they increased the lower border to 15 and even to 18 years of age. The Guidelines of 2005 as well as 2010, recommend

puberty as the border between a child and an adult also giving the rescuer the ability to make his interpretation if having any problems [16,17]. Based on the Guidelines of 2005 and 2010 it is easier for the students to distinguish these victims and begin resuscitation immediately.

- **Assessing level of consciousness.** The students, both first and sixth years assessed the level of consciousness in a child and infant by checking the response to pain, by pinching, pressing, and pricking. This stands in contrast to assessing consciousness in adults, in whom they never used any pain stimulation. The students were not aware of assessing the level of consciousness by checking the response to vocal stimulation. Based on the Guidelines of 2005 and 2010, where no changes were made in assessing the level of consciousness, this question is still interpreted in the same way. The conclusion is that, greater impact should be given to teach students to assess consciousness in children.

- **The rule to call for help for an unconscious child or an infant.** The students were not able to distinguish when to call for help, when they were alone (immediately or after one minute) if the victim was an unconscious adult or a child or an infant. This is because they do not know the common causes of cardiac arrest in adults and in the paediatric victims. They answered wrongly. They would call for help at once, for everyone who is unconscious, particularly for child and infant, because in their opinion these victims suffer from lack of oxygenation. Both first and sixth year students did not know the pathophysiology of cardiac arrest, and they did not understand the difference in the rule concerning calling for help for paediatric victims and for the adults. Guidelines of 2005 and 2010 did not change anything regarding when to call for help (if the rescuer is alone, in children, he has to begin CPR immediately and after one minute should call an ambulance), so this problem is very important and the question is still interpreted the same way.

The answers to the question "what is the rule to call for help for unconscious child and infant" showed that some of the students have not even heard about "call first" and "call fast". It can be explained, that they were not taught the Guidelines of 2000. Particularly sixth year students, who according to the curriculum concentrated on the advanced resuscitation, might not have heard about "call first" and "call fast". This clearly explains that new guidelines, which were the

Guidelines of 2000 at that time, were not taught to them. Unfortunately, at some of the universities graduating students were not acquainted with the changing knowledge of CPR.

- **Opening the airway.** The students did not know that in children, neutral position of the head was recommended to open the airway. They did not know the anatomy of the upper airway in the paediatric victims and how its different when comparing with an adult. Sometimes they explained that they could not tilt the head of the infant so much, because they could injure the spine. This was a stereotype and was rather common among the students. Some students would open the airway of the infant, only by putting a roll under his shoulders, without positioning the hands and fingers on the infant's head, some students would only tilt infant's head, without lifting the jaw, some students wrote, they would open the airway of the infant doing jaw thrust manoeuvre, while they used head tilt-chin lift in the child and adult. I think they were afraid of touching the "small" infant, because they did not acquire this skill well enough and they lacked practice. Guidelines of 2005 and 2010 recommend opening the airway by head tilt-chin lift manoeuvre, with no stronger restriction to prevent so much tilting the head in children [16,17]. This recommendation is unified and seems to be easier for students. This question, if assessed with the new guidelines probably will contain fewer mistakes.

- **Performing chest compressions.** The students did not know how to find the proper place to perform chest compressions in a child or an infant. Sometimes, they wrote that it is as one third of the sternum, but when asked to show it on the manikin, they divided the sternum into three parts. They often made mistakes by mixing up child with the adult, and the child with the infant while performing chest compressions, e.g. they wanted to do chest compressions on the child with two hands like in the adult, and some of the students wanted to do chest compressions on the child with two fingers like in the infant, some of them wanted to find place to do chest compressions in the child drawing a line between the nipples. The Guidelines of 2005 simplified the place to perform chest compressions to the centre of the chest for all the victims. But the Guidelines of 2010 again recommended to find the proper place by sliding one finger on the rib margin to the place where two are meeting and above it on the sternum is a place for chest compressions. The students did not know the

proper rate of chest compressions either for the child or an infant. The rescuer can use one or two hands in children with the same recommended rate (100/min) of chest compressions in all the victims based on the Guidelines of 2005 and rate between 100-120/min according to the Guidelines of 2010 [17,18]. This could have reduced the mistakes made by the students in this question.

- **The cycles if there is only one rescuer.** The students were often confused with the child and the adult, giving the same cycles recommended for the adult (15:2) for the child. They often mixed up with the infant and the newborn, thinking that the cycles recommended for the newborn (3:1), were also good for the infant. Sometimes they wrote, that every victim had the same number of cycles, which is 15:2. Based on the Guidelines of 2005, which simplified the cycles to 30:2 for all the victims (with the exception 15:2 for the children if healthcare providers are present) [16-18], so the cycles are easier to remember. The Guidelines of 2010 have not changed this recommendations [17]. The answer to this question will also contain fewer mistakes, except in the newborns, where different cycles are obligatory.

- **The indications to begin chest compressions.** There were no problems with the indication to begin chest compressions in the adult, but it was not the same with the paediatric victims. The students did not know that, these victims also needed chest compressions while their heart rate was slower than 60/min with not adequate perfusion. This recommendation was written in the Guidelines of 2000. The common mistake, in my opinion, is the process of teaching, during which the students have not been taught additionally the indications to begin chest compressions in the paediatric victims. This recommendation was also contained in the Guidelines of 2005 and 2010, so this question can be interpreted in the same way [16,17].

- **A number of breath/min while circulation is present.** The students would rather hyperventilate the victims than hypoventilate. They wrote, they would give even 40-60 breaths/min in the infant, but did they think that it is possible in basic resuscitation? In the adult e.g. some of the students would give 20-30 breaths/min. In my opinion, the students did not know the pathophysiology and they did not understand the recommendation about number of breaths in the algorithm. If they understood the pathophysiology and if they practised such ventilation on the manikins, they

would know how ventilate the victims and they would remember it for longer time. The Guidelines of 2005 as well as 2010 recommended to avoid hyperventilation [16,17], so mild chest movement of the chest and decreased number of breaths is better than excessive artificial breathing. The mistakes found in this question are still current and important.

- **The potential reversible causes of cardiac arrest.** The students could not write the potential reversible causes of cardiac arrest, which were 4 H's and 4 T's because they did not know them. The Guidelines of 2005 and 2010 also indicated the need to find 4 H's and 4 T's while performing resuscitation. This question is current and its interpretation is still the same.

- **The ways of administration of medications during resuscitation.** The students answered this question well. The ways of medication administration have not changed in the Guidelines of 2005 [16]. The Guidelines of 2010 do not recommend endotracheal route for drug administration [17].

- **A first line drug and its dose in resuscitation.** The students knew this drug and its dose in adults, but they had problems with the dose in children. The Guidelines of 2005 and 2010 also recommended epinephrine as the first drug in children with no changes in the dosage [16,17].

- **The energy used for defibrillation.** The students wanted to use the same energy as recommended for the adults, without counting per kilogram. The Guidelines of 2005 and 2010 recommended one energy level, which is 4J/kg for all the defibrillations [16,17]. This definitely simplifies the algorithm.

When analysing the process of teaching among all the people involved in it we have to consider the problem lying on the teachers. There are some who are not up-to-date with the current guidelines. It can, also explain the lack of knowledge of paediatric CPR among the students. To solve this problem, the teachers should attend mandatory courses in paediatric CPR.

Based on the results it can be concluded that students did not know: the definition of a child and an infant, the rule to call for help, how to open the airway and how to perform chest compressions, the number of breaths/min when circulation is present, the potential reversible causes of cardiac arrest and the first line drug and its dose in resuscitation. If they had practised the scenarios on manikins, they could have remembered the knowledge and skills and would have been able to describe them. One of the major problems could be the

lack of paediatric manikins (probably due to financial constraints).

The "practical" questions showed that problem in teaching skills of CPR, could lie on the teacher as well as on the learning objectives (which do not go into details). The teachers may not be able to correct the performance of the skills by all the students. Few literature shows that "instructors never taught in a standardised way, the practice time was limited and that the errors in performance were not corrected" [23]. J R White et al, when analysed the performance of advanced resuscitation skills, observed "poor performance and the prolonged time to do skill competitions, suggests the need for greater attention to details during training" [24]. This suggestion can be used while teaching paediatric CPR skills. If simple methods like opening the airway and chest compressions were explained in detail by the teacher, practised by every learner and corrected by the teacher at the same time would definitely be more effective.

American Heart Association and European Resuscitation Council authorised paediatric life support courses (basic – PBLs, advanced – PALS). They are performed all over the world with good results. Some studies show their effectiveness [25,26] and mandate people who have worked for a long time without reviewing their knowledge to take the course [27]. C. Alvarez analysed the effectiveness of paediatric CPR training for medical students in PBLs courses with very good result and he suggested this PBLs course as a part of the paediatric curriculum in medical studies [28]. This course should be a part of mandatory education for medical students.

Looking at the common mistakes students made in the written test, the Guidelines of 2005 and 2010 reduce wrong answers and improve the performance of paediatric resuscitation. So the students will not spend more time thinking if the victim is a child or an adult, how to open the airway or how and where begin doing chest compressions.

Conclusions

The effectiveness of teaching paediatric CPR of the tested groups was different. A correlation between the possessed knowledge of adult's and paediatric resuscitation was found. Students were better prepared to perform resuscitation on the adults than on children and they knew advanced CPR better than basic CPR.

Negative factors, which influenced the process of teaching could be the lack of paediatric CPR in the curriculum, not enough universities were equipped with paediatric manikins and the teachers were not adequately prepared with the recent changes to the guidelines.

Based on the results and discussion these conclusions were made:

1. First and sixth year medical students from four Universities did not know paediatric resuscitation well enough. There is a need to improve the curriculum of basic and advanced paediatric resuscitation at the universities. If not adequate time is spend for paediatric resuscitation in curriculum, the results will be poor and the medical students will not be well prepared for performing resuscitation on children and infants.
2. All the Universities should be equipped with paediatric manikins, so that medical students would be able to acquire the skills in paediatric resuscitation.
3. All the teachers who teach paediatric resuscitation to medical students should attend mandatory courses in this field to be familiar with the latest changes in the guidelines.
4. The Guideline of 2005 and 2010 simplified paediatric resuscitation.

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Konflikt interesów / Conflict of interest

Brak/None

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