Acta Biomed for Health Professions 2018; Vol. 89, S. 4: 37-44 DOI: 10.23750/abm.v89i4-S.7129

A randomized comparison trial of two and four-step approaches to teaching Cardio-Pulmonary Reanimation

Giorgio Lapucci[1], Barbara Bondi[2]*, Ivan Rubbi[3]*, Valeria Cremonini[3], Erica Moretti[4], Rosaria Di Lorenzo[5], Daniela Magnani[6], Paola Ferri[6]*

[1]Emergency Medicine Physician (EMP), Instructor AIEMT of Ravenna; [2] Organizational Development, Training and Evaluation AUSL of Romagna; [3] School of Nursing, University of Bologna, Bologna, Italy; [4] Neonatology, AUSL of Romagna; [5] Department of Mental Health, Local Health Authority (AUSL) of Modena and School of Nursing, Department of Diagnostic, Clinical and Public Health Medicine, University of Modena and Reggio Emilia, Modena, Italy; [6]School of Nursing, Department of Diagnostic, Clinical and Public Health Medicine, University of Modena and Reggio Emilia, Modena, Italy

Abstract. *Background and aim of the work:* The treatment of cardiac arrest in an extra-hospital environment improves with the increase in the number of people able to establish an early Cardio-Pulmonary Reanimation (CPR). The main aim of the study was to assess the validity of the two-step method in case of prolonged CPR. *Methods:* A randomized comparison study was conducted in the University Nursing School of a Northern Italian town, during the 2015/16 academic year, among 60 students, to teach them CPR techniques, through two different teaching methods (4-step and the 2-step of CPR training). The effectiveness of the maneuvers performed on mannequins equipped with skill-meter was verified. *Results:* Our study did not highlight any significant difference between the two methods of CPR training. The comparison between the two methods regarding their efficacy in practical teaching of CPR, highlighted by this study, proved the validity of both the 4-minute continuous method (1st method) and the 30:2 method (2nd method). *Conclusions:* The results of the study showed no differences between the 2-step and the 4-step methods, in the effectiveness of cardiac massage. The correct execution of chest compressions during a CPR is the key to increase the patient's chances of rescue. Research has shown that any interruption in the execution of chest compressions, leads to a progressive reduction of the effectiveness of cardiac massage, with negative consequences on the prognosis of the patient undergoing at CPR.

Key words: 4-Step, 2-Step, Cardiopulmonary Resuscitation, Out-of-Hospital Cardiac Arrest, Teaching, Nursing student

Background

Extra-hospital cardiac arrest is still a serious public health problem. The metaphor of the "Chain of Survival", coined by the American Heart Association (AHA) and universally adopted, identifies the basic phases for successfully resuscitating victims of cardiac arrest (1). Identifying cardiac arrest can be difficult. Both bystanders and those who manage the emergency calls must immediately recognize cardiac arrest in order to promptly activate the survival chain (2). The key symptoms for recognizing a cardiac arrest are: the victim is unresponsive, does not breathe normally and does not show any signs of circulation (3, 4).

Unfortunately, only at times bystanders start Cardio-Pulmonary Reanimation (CPR) on their own in

* Lapucci G., Bondi B. and Rubbi I. contributed equally and therefore share first authorship

case of cardiac arrest. It has been demonstrated that CPR telephonically guided by the emergency operative center increases the survival rate (2), reduces the time that elapses between cardiac arrest and the beginning of the first chest compression (5, 6), increases the number of chest compressions performed (7) and improves the prognosis of victims of extra-hospital cardiac arrest (8-10). The emergency center operators should provide instructions to perform CPR with chest compressions only if the cardiac arrest victim is an adult. Immediate CPR can double or quadruple survival after cardiac arrest (11, 12).

The European Resuscitation Council (ERC) supports the recommendations of the International Liaison Committee on Resuscitation (ILCOR), according to which a chest compression with a depth of about 5 cm but no more than 6 cm, is reasonable in the average adult (13). A frequency of at least 100 compressions per minute, without exceeding 120 compressions per minute, with the fewest interruptions possible (14), and with equal times for the compressions and release phases is optimum (15, 16). Teaching CPR is fundamental for training and the most effective method for training it should be identified (17). A model that has been increasingly affirmed in medical and university training since 2000 is Peyton's *Four Step Approach*, a 4-step method of instruction, normally used in the training courses of the European Society of Cardiology (ESC)(18).

The 4-step teaching method developed by Peyton provides the following sequence:

- phase 1: technique performed by the instructor in real time and in silence;
- phase 2: CPR is repeated and commented by instructor with explanations of reasons for each action;
- phase 3: the demonstration is repeated by the instructor under the direction of one of the learners;
- phase 4: the execution of the phase is repeated by a learner.

Although this approach is theoretically very convincing, as a cognitive procedural model there is no evidence that it leads to superior results in terms of learning compared to other teaching methods (19). Several studies compared the effectiveness of the 4-step method with other teaching models. Greif's randomized controlled trial compared the Peyton 4-step teaching method with the traditional "*see one, do one*" method to teach a specific technical skill such as cricothyroidotomy (20). Orde's study compared the 4-step teaching method with the traditional 2-step method for inserting the laryngeal mask (21). Orde's training method uses steps 2 and 4 of the Peyton 4-step method. The study did not show a statistically significant difference between the 2- and 4-step methods either in terms of acquiring the skill or remembering it over time.

Aim

The main aim of the study was to assess the validity of the two-step method in case of prolonged CPR. Secondary aims were:

- to verify if periodic two-second interruptions every thirty chest compressions allow the rescuer to maintain an effective cardiac massage for a longer time, regardless of whether the ventilations are performed or not;
- to verify if a feedback system on the effectiveness of chest compressions (Skill-meter®) has a positive influence on massage efficacy.

Method

Study design and participants

This randomized comparison trial was conducted in the University Nursing School of a Northern Italian town, during the 2015/16 academic year. Our convenience sample consisted of 60 nursing students: 25 in the first year and 35 in the second year of Nursing course. The students of our sample had never performed CPR.

The sample was randomly divided into two numerically homogeneous groups of thirty students: the experimental and the control group. For allocation of the participants, a computer-generated list of random numbers was used. The two initial groups were subsequently divided into three subgroups composed of 10 students each in order to make teaching easier by reducing the ratio of instructor: students to 1:10.

1st Phase of the study

Before starting the experiment, the 8 CPR instructors were divided into 3 randomized instructor groups: three instructors composed the experimental group aimed at teaching only 2 of the 4 CPR steps described by Peyton, the other three instructors composed the control group to teach the traditional four-step CPR method and the last two instructors composed the evaluation group with the task of evaluating all students' performance (18). The three groups were double-blinded since the instructors of each group did not know the teaching methodology of the other groups. Moreover, instructors and students were not allowed to attend the other groups' training and performance.

Before the beginning of the training, each instructor was asked to simulate his/her activities to other instructors in order to ensure that performances were homogeneous. Eight work stations were created, six for student training of and two for instructors' evaluation. All settings were equipped with ResusciAnne® manikin with Skill-meter®, self-expanding balloon with a medium-sized mask. All the equipment, manufactured by the same company, presented the same technical characteristics.

The research protocol provided for the following proceduresfor each group:

- 15 minutes of training for cardiac massage and ventilation with ambu bag;
- access of three students maximum at a time to each workstation.

After completing the training, the students were randomly sent to the two evaluation stations, where their 2-minute CPR performances were assessed by the two instructors (Figure 1).

2nd Phase of the study

After completing the first phase of the study, the two training methods were compared to evaluate the

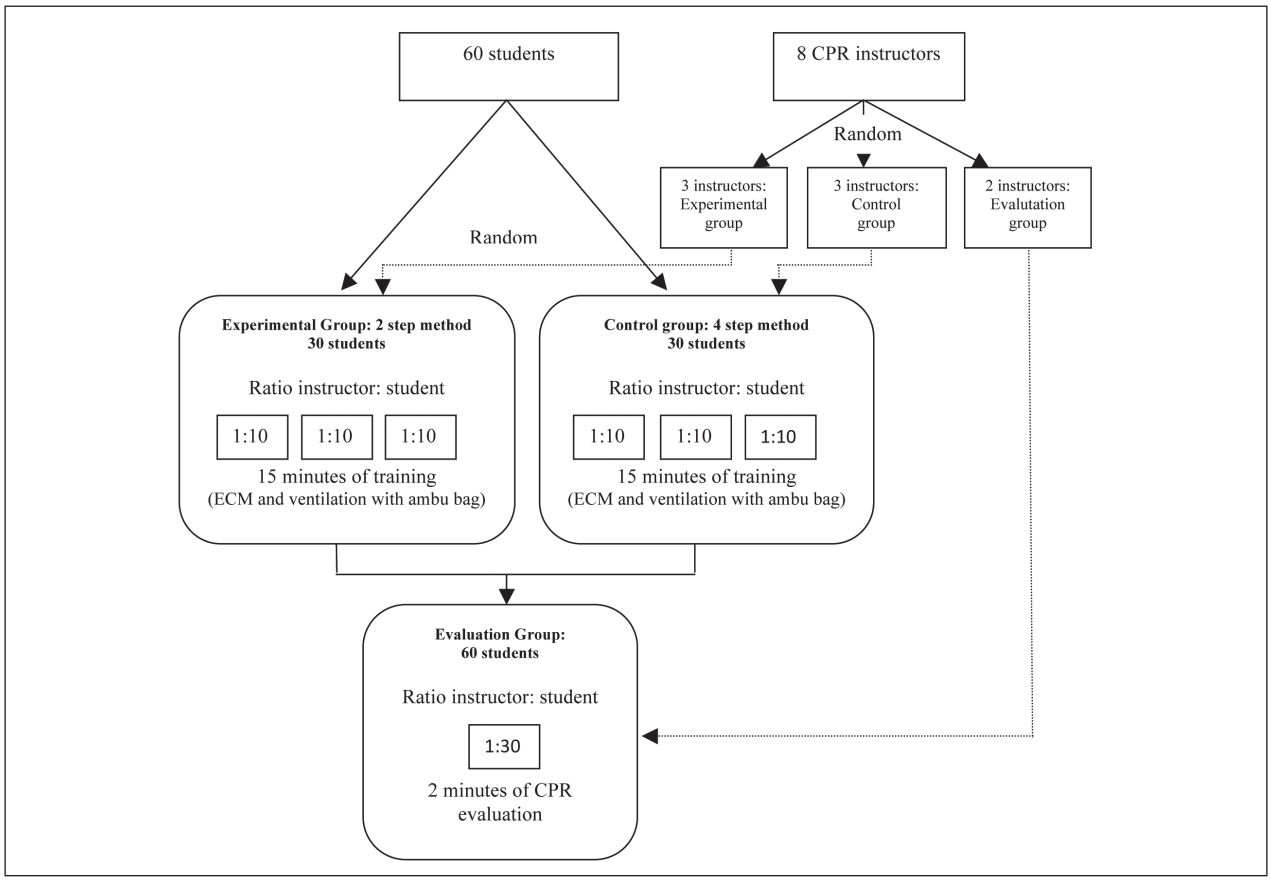

Figure 1. 1nd Phase of the study

better one for carrying out the External Cardiac Massage (ECM). Method 1 provided the execution of 4 minutes of uninterrupted ECM either with or without the aid of an evaluation tool during practice. Method 2 provided the execution of ECM for 4 minutes with a pause of 2 seconds (theoretical time for the ventilations) every 30 compressions. In this case also the experiment took place either with or without the aid of an evaluation tool. The 8 CPR instructors were randomly divided into four groups (two groups per each method) and the 60 students were numerically homogeneously inserted into the four groups (15 students per group). Two work stations were assigned to each group. The students assigned to the two groups of Method 1 were asked to practice ECM by checking the Skill-meter® for 1 minute; after this, one group continued to practice the cardiac massage with only the aid of a metronome, whereas the other group practiced ECM for 4 minutes supported by both metronome sound and Skill-meter® monitor.

The students inserted in the two groups of Method 2 were asked to practice ECM by checking the Skill-meter® for 1 minute; after this, one group continued to practice the cardiac massage with the aid of only a metronome, whereas the other group practiced ECM for 4 minutes supported by both metronome sound and Skill-meter® monitor. For both training methods, each student was given 5 minutes of time (Figure 2).

Data from the 1st and 2nd phases of the study were collected on two electronic boards. For each student, we collected personal data, height, weight and his/her performance of ECM (number of massages with insufficient force on the chest of the manikin, the number of massages with excessive force exerted and the correct ECMs) and ventilation (number of insufflation with insufficient pressure to fill the lungs, number of insufflation with excessive pressure and number of correct insufflations).

Ethical considerations

All students enrolled gave us their informed written consent for participation in this study, following our explanation of its purpose and design. Participants' anonymity and confidentiality were assured and their decision regarding participation in this study was respected. The study was authorized by the Director of the Nursing Degree Programme.

Statistical analyses

Descriptive statistical analyses were performed: means and standard deviations for continuous data,

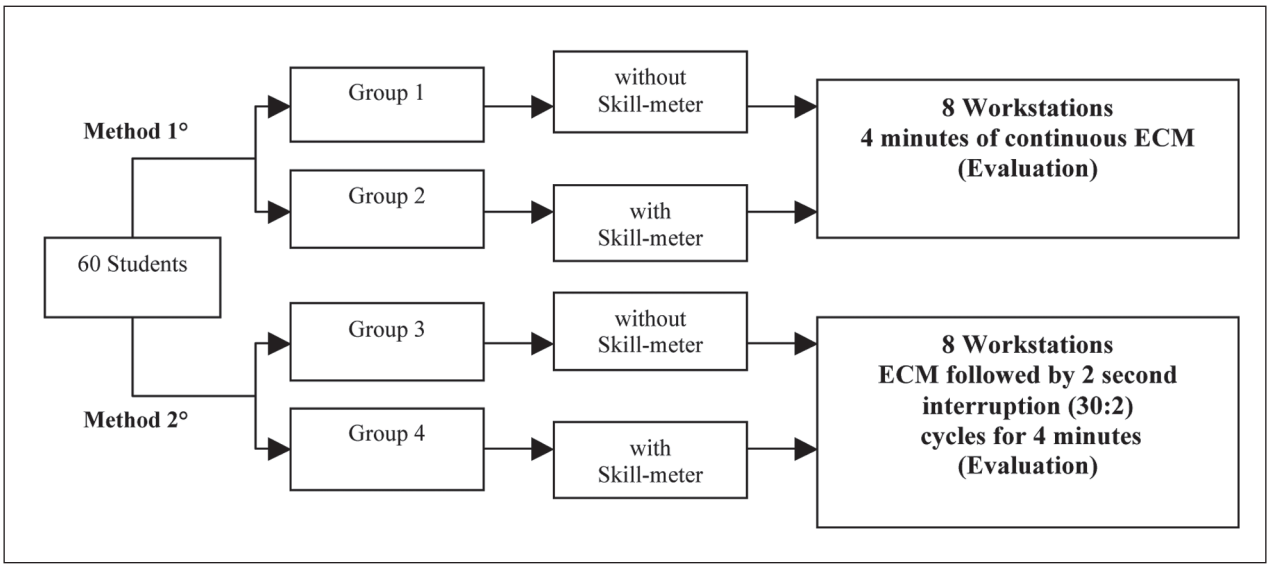

Figure 2. 2st Phase of study

and percentages for categorical data. *t*-test and ANOVA were applied to identify significant differences among continuous data. Categorical variables were calculated through the contingency tables and the differences were detected through the Chi-square. Multiple comparisons were performed using Tukey's Honestly Significant Difference (HSD). We considered statistical significance to have been attained if $p < .05$. The statistical analysis was performed using the SPSS software.

Results

Sixty students were enrolled in the study: 10 males (16.7%) and 50 females (83.3%). The mean age of our sample was 22.03 years on average (*SD*=4.403). Regarding the physical characteristics of the students (Table 1), divided by gender, significant differences were found both in weight (p=.0001) and height (p=.0001), as highlighted by another study (21).

In our sample, the efficacy in performing CPR was not influenced by gender, weight or height of students. Regarding the two methods of CPR, the *t*-test did not show any significant difference (p=.885), although the number of effective chest compressions was higher in the 2-step method (*M*=75.24, *SD*=33.56) than in the 4-step method (*M*=73.30, *SD*=32.03) (Table 2).

Table 1. Constitutional variables of our sample

	Males n=10	Females n=50	Total n=60	Statistical test Probability
Weight (Kg), n (%)				
40-50	0 (0)	10 (20)	10 (17)	
51-60	1 (10)	35 (70)	36 (60)	χ^2=33.4
61-70	5 (50)	4 (8)	9 (15)	p=.0001
71-80	1 (10)	1 (2)	2 (3)	
81-90	2 (20)	0 (0)	2 (3)	
91-100	1 (10)	0 (0)	1 (2)	
Height (cm), n (%)				
150-160	0 (0)	22 (44)	22 (37)	
161-170	3 (30)	27 (54)	30 (50)	χ^2=34.8
171-180	4 (40)	1 (2)	5 (8)	p=.0001
181-190	3 (30)	0 (0)	3 (5)	

In the second experiment, the number of chest compressions statistically significantly differed between the two methods (t=2.936, p=.005). In fact, the simulator calculation of the average of the total chest compressions performed, demonstrated that, with the 1st method, the students performed an average of 409.96 compressions (*SD*=28.90), while with the 2nd method, the average number of compressions was 386.28 (*SD*=33.01).

Regarding the efficacy of the chest compressions, there were no differences between the 1st teaching method and the 2nd one (Table 3). However, 4-min-

Table 2. Comparison of chest compression and ventilation effectiveness in the 2 and 4 step methods

	N	M±SD	Standard error	Statistical test Probability
Insufficient chest compressions				
4 – step method	16	39.93±33.30	8.474	t=.512
2 – step method	17	33.59±37.13	9.006	p=.612
Too strong chest compressions				
4 – step method	6	29.00±28.06	11.457	t=.148
2 – step method	6	26.50±30.35	12.390	p=.885
Effective chest compressions				
4 – step method	30	73.30±32.03	5.848	t=-.227
2 – step method	29	75.24±33.57	6.233	p=.821
Effective ventilations				
4 – step method	30	7.97±3.09	.564	t=-.223
2 – step method	29	8.14±2.79	.517	p= .824

Table 3. Comparison of the chest compression effectiveness in the 2 and 4 step methods

	N	M±SD	Standard error	Statistical test Probability
Insufficient chest compressions				
4 – step method	28	160.54±12.72	22.814	*t*=-.838
2 – step method	31	188.06±130.52	23.443	*p*=.405
Too strong chest compressions				
4 – step method	5	22.60±37.30	16.681	*t*=.929
2 – step method	5	7.00±4.47	2.000	*p*=.380
Effective chest compressions				
4 – step method	28	243.00±115.93	21.910	*t*=1.251
2 – step method	32	203.19±128.78	22.766	*p*=.216

ute uninterrupted massage for 4 minutes (Method 1) produced better results: effective massages were 243 on average (*SD*=115.93), which corresponded to 59.3% of the average total compressions performed with the 1st method, against 203.19 massages on average (*SD*=128.78) of the ECM followed by interruption (30:2), method 2, which instead corresponded to 52.3% of all massages performed with the 2nd method.

Regarding the use of the skill-meter, group 2 obtained the highest number of effective chest compressions (306.60±86.83, *p*=<.0001); it practiced the massage in 4 minutes without interruption with skill-meter support, reporting a percentage of 74.8% correct compressions; group 4 follows, with 66.8% correct massages (257.29±110.55) (Figure 3).

However, the multiple comparison showed significant differences between group 2 and group 1 (MD=-134.979, *p*=.012) as well as between group 2 and group 3 (MD=-147.533, *p*=.003), but not between group 1 and group 4 (MD=98.534, *p*=.095).

Discussion and conclusions

Our study did not highlight any significant difference between the 4-step and the 2-step methods

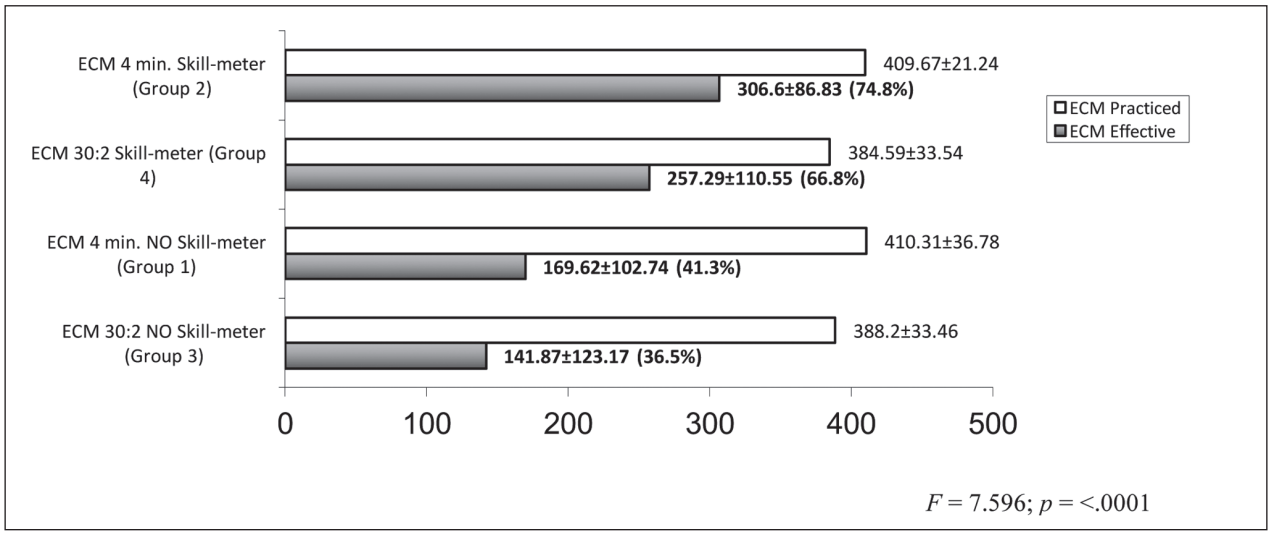

Figure 3. Effectiveness of chest compressions in the two training methods, with or without use of the skill-meter

of CPR training. Therefore, the results obtained from this research suggest the validity of the Orde 2-step method (22) as well as the Peyton 4-step method. This result was further confirmed by the comparison between the two methods regarding the efficacy of chest compressions and ventilations and errors recorded by the simulators' skill-meters. Differently from a recent study (21), the personal and physical characteristics of our students did not affect their training performances in CPR.

Furthermore, the 2-step method permitted students to have more time to perform the practical maneuvers through the simulator, whereas the instructor had more time to do corrective interventions. For this reason, the 2-step method could be useful for health care workers and non-professionals who need practical training in CPR maneuvers and airway management (22). Moreover, we suggest that the choice between the Peyton and Orde method could depend on the organizational peculiarities of health setting or training course that promotes training.

The comparison between the two methods regarding their efficacy in practical teaching of CPR, highlighted by this study, proved the validity of both the 4-minute continuous method (1st method) and the 30:2 method (2nd method).

Finally, we suggest that the choice between the 1st or 2nd method could be inferred from the results obtained by the four groups of our students who used the Skill-meter® during CPR. In fact, our results highlighted the effectiveness of both methods in groups 2 and 4, where students used the Skill-meter®. This result indirectly suggests that the correct choice of teaching method depends on the availability of simulator equipment and not on the typology of method: for health settings or institutions with low technology instruments, which do not permit the evaluation of students' performances during chest compressions, the method which involves 4 uninterrupted minutes of massage could be preferred, whereas, the availability of medium-high technology simulators, could permit the use of the traditional 30:2 method.

We conclude by highlighting that both clinical learning and competency development are essential parts of nursing teaching (23) and realistic simulation can be an effective training method, especially if it is supported by the presence of trained instructors (24, 25).

The main limit of the study was represented by the small size of our sample, not homogenous for gender but only for age. Furthermore, the skill retention after a period of time was not verified due to the difficulty to collect the same sample in a follow-up (most of students subsequently participated in complete CPR course, or they began working, or transferred to other locations).

To confirm our results, further studies with bigger sample, including subjects with different professional and personal characteristics, are necessary.

References

1. Nolan J, Soar J, Eikeland H. The chain of survival. Resuscitation 2006; 71: 270-1.
2. Vaillancourt C, Verma A, Trickett J, et al. Evaluating the effectiveness of dispatch-assisted cardiopulmonary resuscitation instructions. Acad Emerg Med 2007; 14: 877-83.
3. Sasson C, Rogers MA, Dahl J, Kellermann AL. Predictors of survival from out-of-hospital cardiac arrest: a systematic review and meta-analysis. Circ Cardiovasc Qual Outcomes 2010; 3: 63-81.
4. Takei Y, Nishi T, Kamikura T, et al. Do early emergency calls before patient collapse improve survival after out-of-hospital cardiac arrests? Resuscitation 2015; 88: 20-7.
5. Rea TD, Eisenberg MS, Culley LL, Becker L. Dispatcher-assisted cardiopulmonary resuscitation and survival in cardiac arrest. Circulation 2001; 104: 2513-6.
6. Tanaka Y, Taniguchi J, Wato Y, Yoshida Y, Inaba H. The continuous quality improvement project for telephone-assisted instruction of cardiopulmonary resuscitation increased the incidence of bystander CPR and improved the outcomes of out-of-hospital cardiac arrests. Resuscitation 2012; 83: 1235-41.
7. Akahane M, Ogawa T, Tanabe S, et al. Impact of telephone dispatcher assistance on the outcomes of pediatric out-of-hospital cardiac arrest. Crit Care Med 2012; 40: 1410-6.
8. Hupfl M, Selig HF, Nagele P. Chest-compression-only versus standard cardiopulmonary resuscitation: a meta-analysis. Lancet 2010; 376: 1552-7.
9. Bray JE, Deasy C, Walsh J, Bacon A, Currell A, Smith K. Changing EMS dispatcher CPR instructions to 400 compressions before mouth-to-mouth improved bystander CPR rates. Resuscitation 2011; 82: 1393-8.
10. Stipulante S, Tubes R, El Fassi M, et al. Implementation of the ALERT algorithm, a new dispatcher-assisted telephone cardiopulmonary resuscitation protocol, in non-Advanced Medical Priority Dispatch System (AMPDS) Emergency Medical Services centres. Resuscitation 2014; 85: 177-81.

11. Holmberg M, Holmberg S, Herlitz J; Swedish Cardiac Arrest Registry. Factors modifying the effect of bystander cardiopulmonary resuscitation on survival in out-of-hospital cardiac arrest patients in Sweden. Eur Heart J 2001; 22: 511-9.
12. Hasselqvist-Ax I, Riva G, Herlitz J. Early cardiopulmonary resuscitation in out-of-hospital cardiac arrest. N Engl J Med 2015; 372: 2307-15.
13. Hellevuo H, Sainio M, Nevalainen R, et al. Deeper chest compression - more complications for cardiac arrest patients? Resuscitation 2013; 84: 760-5.
14. Idris AH, Guffey D, Pepe PE, et al. Chest compression rates and survival following out-of-hospital cardiac arrest. Crit Care Med 2015; 43: 840-8.
15. Yannopoulos D, McKnite S, Aufderheide TP, et al. Effects of incomplete chest wall decompression during cardiopulmonary resuscitation on coronary and cerebral perfusion pressures in a porcine model of cardiac arrest. Resuscitation 2005; 64: 363-72.
16. Niles DE, Sutton RM, Nadkarni VM, et al. Prevalence and hemodynamic effects of leaning during CPR. Resuscitation 2011; 82 Suppl 2: S23-6.
17. Münster T, Stosch C, Hindrichs N, Franklin J, Matthes J. Peyton's 4-Steps-Approach in comparison: Medium-term effects on learning external chest compression - a pilot study. GMS J Med Educ 2016; 33: Doc60.
18. Nikendei C, Huber J, Stiepak J, et al. Modification of Peyton's four-step approach for small group teaching - a descriptive study. BMC Med Educ 2014;14: 68.
19. Sopka S, Biermann H, Rossaint R, et al. Evaluation of a newly developed media-supported 4-step approach for basic life support training. Scand J Trauma Resusc Emerg Med 2012; 20: 37.
20. Greif R, Egger L, Basciani RM, Lockey A, Vogt A. Emergency skill training--a randomized controlled study on the effectiveness of the 4-stage approach compared to traditional clinical teaching. Resuscitation 2010; 81: 1692-7.
21. Schröder H, Henke A, Stieger L, et al. Influence of learning styles on the practical performance after the four-step basic life support training approach - An observational cohort study. PLoS One 2017; 12: e0178210.
22. Orde S, Celenza A, Pinder M. A randomised trial comparing a 4-stage to 2-stage teaching technique for laryngeal mask insertion. Resuscitation 2010; 81: 1687-91.
23. Magnani D, Di Lorenzo R, Bari A, Pozzi S, Del Giovane C, Ferri P. The undergraduate nursing student evaluation of clinical learning environment: an Italian survey. Prof Inferm 2014; 67: 55-61.
24. Cremonini V, Ferri P, Artioli G, Sarli L, Piccioni E, Rubbi I. Nursing students' experiences of and satisfaction with the clinical learning environment: the role of educational models in the simulation laboratory and in clinical practice. Acta Biomed 2015; 86 Suppl 3: 194-204.
25. Rubbi I, Ferri P, Andreina G, Cremonini V. L'apprendimento clinico in simulazione: studio osservazionale sulla soddisfazione percepita dagli studenti di infermieristica [Learning in clinical simulation: observational study on satisfaction perceived by students of nursing]. Prof Inferm 2016; 69: 84-94.

Correspondence:
Rubbi Ivan
University of Bologna - Campus of Ravenna - Nursing School, via Mura Diamante Torelli 67
48018 Faenza (Ravenna) Italy
E-mail: ivan.rubbi@auslromagna.it