RESEARCH ARTICLE

Evaluating the retention of skills in postgraduate physician students following a theoretical-practical course in Advanced Cardiovascular Life Support [version 1; peer review: 4 approved with reservations]

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Abstract

Background: For every minute CPR is delayed, the probability of survival decreases by up to 10%. For this reason, guidelines recommend routine CPR training for health care providers to improve their performance and patient results. The objective of the present study was to evaluate the retention capacity of postgraduate students of Critical Areas of the Pontificia Universidad Católica del Ecuador following a theoretical-practical course in Advanced Cardiovascular Life Support (ACLS).

Methods: A total of 140 students were recruited and divided into three groups according to studied subject: Emergency Medicine and Disasters, Anesthesiology, and Critical Medicine. A theoretical-practical course was carried out, and theoretical and practical skills were assessed immediately and subsequently one month after ACLS training. For statistical analysis, measures of central tendency, one-way ANOVA, T-test and ANCOVA were used.

Results: Scores for the immediate theoretical exam were 58.6% immediately after the intervention vs 40% 30 days after the intervention; in the immediate practical exam this was 77% vs 35.7%, respectively. No statistically significant difference was found between the three groups for the initial practical examination; however, for the evaluation 30 days after training a significant difference was found between Anesthesiology and the other two postgraduate studies.

Conclusions: Knowledge and practical skills in ACLS of postgraduate

Open Peer Review

Approval Status

	1	2	3	4
version 1				
12 Apr 2019	view	view	view	view
1. William D. Grant , State University of New York Upstate Medical University (SUNY Upstate Medical University), Syracuse, USA				
2. Eduardo Kattan , Pontifical Catholic University of Chile, Santiago, Chile				
3. Marcia A. Corvetto , Pontifical Catholic University of Chile, Santiago, Chile				
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Any reports and responses or comments on the article can be found at the end of the article.

physicians of Critical Areas deteriorate 30 days after training, especially in practical skills compared with theoretical knowledge. The results of this research indicate that it is necessary to carry out update courses more frequently, in order to keep knowledge and skills at a level that guarantees adequate care to the patient to reduce potential risk of death or disability.

Keywords

Advanced Cardiovascular Life Support, ACLS, Cardiopulmonary Resuscitation, Critical Areas

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Introduction

Deaths related with cardiovascular disease occur at earlier ages in developing countries. In Latin America and the Caribbean, men are at risk of premature death as a result of this disease, although in recent years the rate has increased in women¹. People who are victims of cardiovascular disease face difficulties due to the disability of the disease, which affects their families and the economy. According to the World Health Organization, the mortality rate in the Americas in 2016 with regard to ischemic heart diseases, cerebrovascular diseases and diabetes mellitus was 63.1, 35.2 and 33.5, respectively, out of 1000,000¹. Between the years 2010 and 2013, ischemic heart diseases were the leading cause of death in the Americas (10.99%), followed by cerebrovascular diseases (6.70%) and diabetes mellitus (5.49%)². Just in Ecuador, the number of deaths from heart disease in 2010 was 11992 (51.68% in men and 48.32% in women)³.

Mortality from arterial hypertension, cerebrovascular disease and diabetes mellitus has increased in general⁴; therefore, it has been found that adequate knowledge in cardiopulmonary resuscitation (CPR) is essential in order to reduce mortality caused by these conditions. The early onset of CPR and defibrillation are important and necessary for the reduction of morbidity-mortality in patients with cardiorespiratory arrest. For every minute CPR is delayed, the probability of survival decreases by up to 10%. For this reason, guidelines recommend routine CPR training for health care providers to improve their performance and patient results^{5,6}.

In the present study, the retention capacity of the Advanced Cardiovascular Life Support (ACLS) course was evaluated in postgraduate students of Critical Areas of the Pontificia Universidad Católica del Ecuador.

Methods

Participants and study setting

The study was conducted between January and February of 2017 at the Pontificia Universidad Católica del Ecuador, Quito-Ecuador. A total of 219 students from critical areas (Emergencies and Disasters, Intensive Care and Anesthesiology) were involved in the study. Taking a heterogeneity of 50%, with a margin of error of 5% and a level of confidence of 95%, the sample was 140 students. For the selection of the sample, randomized sampling was carried out. Groups of 7 people were organized for each evaluator in a random manner, with a total of 14 participants per day, ending at the 10th day with the 140 participants. Eligibility criteria: post-graduate students from the critical areas who wished to participate in the study, and who were not on duty at time of the intervention.

The students were identified and invited to the courses from the university "Pontificia Universidad Católica del Ecuador" database (postgraduate students from critical areas). Every student has to pass these tests at least once during their studies according to the University's requirements. The participation in the study was voluntary.

Theoretical-practical course

Informed written consent was obtained from the participants prior to the study start.

A theoretical-practical ACLS course was provided to postgraduate-students of Medicine at Pontificia Universidad Católica of Ecuador according to 2015 Guidelines ACLS Course. A theoretical and practical post-test was provided to the participants according to the 2015 RCP guidelines. The instructors were certified in ACLS and Basic Life Support (BLS) with experience in the practice, teaching and performance evaluation.

The participants had a theoretical assessment in the first 10 minutes (see *Extended data*⁷) to determine prior knowledge in ACLS, then for 1 hour 30 minutes a theoretical intervention based on Adult Cardiac Arrest Algorithm-2015 (Update of the American Heart Association (AHA) was performed with the participants.

Later an practical intervention, where simulated practical cases were performed, was provided in order to develop the skills required to administer high-quality cardiopulmonary resuscitation together with the adequate recognition of defibrillable and non-defibrillable rhythms, according to the 2015 AHA guidelines.

Theoretical standardized tools were used for evaluating the course received. All the tests used the same scenarios, AHA's Skill Assessment List (practices), and private simulation environments, using mannequins and tools.

The exam results were expressed in percentage according to the ACLS book for instructors⁸, that states that 84% must be reached for the theoretical exam; and all the steps of the checklist must be met to pass the practical exam. The checklist to evaluate the practical test is available in *Extended data*⁹.

After 30 days, the theoretical and practical evaluation was carried out once again for each of the participants.

Data analysis

Cohen Kappa index was initially performed to determine the concordance and standardization of the knowledge taught in the intervention. The result was 0.828, which indicates a high agreement between the two instructors¹⁰; therefore, it was possible to continue with the study.

The average results of the first evaluation were compared with the average results of the second evaluation (30 days after intervention). Central tendency and dispersion tests were performed, as well as Student's t-test, one-way ANOVA and ANCOVA. The statistical analysis was carried out using the SPSS software version 24.0.

Results

The characteristics of the participants are detailed in *Underlying data*¹¹. There were statistically significant differences in the

test scores between the subject groups for the first theoretical test immediately after the ACLS course. It was observed that these differences were between the Emergencies and Disasters and Anesthesiology groups ($p < 0.05$), as well as between the Critical Medicine and the Anesthesiology groups ($p = 0.027$). No statistical difference was seen between the Emergencies and Disasters and Critical Medicine groups. Likewise, for the second theoretical test score (30 days after the ACLS course), a statistical difference was seen between the Emergencies and Disasters and Anesthesiology groups ($p < 0.05$), and the Critical Medicine and Anesthesiology groups ($p = 0.020$), but not between the Emergencies and Disasters and Critical Medicine groups ($p = 0.539$).

There was no statistically significant differences in the first practical examination between the groups when evaluating their practical skills acquired immediately after the intervention of ACLS ($p = 0.066$). However, in the second practical examination assessed after 30 days of the initial intervention, statistically significant differences were identified. When conducting the post-hoc test through Scheffe, it was observed that there were differences in the level of practical skills between the Emergencies and Disasters and Anesthesiology groups ($p = 0.04$), as well as between the Critical Medicine and Anesthesiology groups ($p = 0.013$). A statistically significant difference was not observed between the Emergencies and Disasters and Critical Medicine groups ($p = 0.994$).

For all students for the theoretical examination, there was a decrease in the result (Table 1) between the test carried out immediately after the intervention (mean = 83.43) and 30 days after the intervention (mean = 76.21) ($p < 0.05$). In the practical examination, a statistically significant decrease was found in the result between the test carried out immediately after the intervention (mean = 93.81) and 30 days after the intervention (mean = 75.71) ($p < 0.05$).

Finally, a covariance analysis (ANCOVA) was performed for the results of the theoretical and practical examinations after 30 days of the intervention on ACLS, in order to investigate whether the relationship between the variables found is maintained when controlling the effect (introducing them as covariates) (*Underlying data*⁷).

Significant variables for scores in the theoretical test after 30 days were: age and sex of the participant, stress, year of the postgraduate course, validity of the certificate in ACLS, number of times that the person used the information from the ACLS

course during clinical practice, if they were instructors of ACLS, and regularity of the studies. No statistically significant differences were found in relation to rest during the previous night in the results of written examination. Unlike the results of the theoretical examination, no statistically significant differences were found in the participant's post-shift status in the 30-day practical evaluation.

Discussion

There are international organizations, such as the American Heart Association, which have developed cardiopulmonary resuscitation treatment programs; at Pontificia Universidad Católica del Ecuador, it is considered essential in undergraduate with Basic Life Support (BLS) program and postgraduate (BLS and ACLS Advanced Cardiovascular Life Support) training. However, these are no courses carried out in health centers where these students receive their daily training, instead these are organized by scientific companies.

The present study is the first study, to the best of our knowledge, carried out in Ecuador that compares the retention of theoretical and practical knowledge of postgraduate students in Critical Areas courses, including Emergencies and Disasters, Anesthesiology and Critical Medicine. These students are the ones who have the highest possibility of facing situations that require advanced cardiovascular care.

The findings of this study are consistent with previous literature that has shown that the knowledge and practical skills of health providers have been reduced before the recommended training interval (2 years). The average in which this reduction is observed is between 6 months to 1 year^{10,12}; however, there are not many previous studies that indicate the behavior between 1 to 6 months.

In the present study, the participants' theoretical evaluations showed an average of 83.43% immediately after the intervention, and 76.21% in the 30-day post intervention evaluation. The practical examination showed an average of 93.81% immediately after, and 75.71% at 30 days; therefore, it is concluded that practical skills have more declination than theoretical knowledge, which agrees with the literature, which indicate that practical skills are more affected over the time¹²⁻¹⁶, and also that the results of theoretical examinations are not good predictors of practical evaluation results¹⁷. In this study, the most impaired practical skills were: treatment according to the rhythm of arrest, ensure scene, perform aftercare and adequate recognition of arrest rhythms. These findings suggest that

Table 1. Average results of evaluations by critical areas (%).

Evaluation	Emergencies and Disasters (%)	Anesthesiology (%)	Critical Medicine (%)	Total (%)
Theoretical 1	86.36	77	84	83.43
Theoretical 2	79.57	68.86	76.86	76.21
Practical 1	93.65	90.47	97.46	93.81
Practical 2	79.20	64.75	79.68	75.71

appropriate intervals and re-training strategies should be differentiated between knowledge and skills, with reinforcement of the latter.

Comparing the three postgraduate groups in Critical Areas, it was found that the Emergency and Disaster and Critical Medicine groups did not have statistically significant differences in the knowledge of both written and practical evaluations within 30 days of the intervention. However, it was observed that there is a difference between the Anesthesiology group with the other two groups ($p < 0.05$). Similar results were observed in the study carried out by Botha *et al.* (2012) in which the participants of Emergency Medicine had a better overall performance in the evaluations with respect to the participants of Anesthesiology, taking into account that they both belong to Critical Areas¹⁸. The reason for having less retention in this group can be explained by several factors, including the low incidence of patients with cardiorespiratory arrest in operating rooms, where anesthesiologists perform their daily work. In a study conducted by An *et al.* (2011) in Pittsburgh, USA, 23 cases of intraoperative cardiac arrest of a total of 218274 patients were found, resulting in a prevalence of 1.1 cases for 10000¹⁹. Hence, the application of the Adult Cardiac Arrest Algorithm-2015 Update of the American Heart Association for Advanced Cardiovascular Life Support (ACLS) will be very infrequent and will not be enough to maintain knowledge and skills. Conversely in Department of Emergencies and Intensive Care Unit, 42% of all hospital cardiac arrests are recorded in these departments according to a study conducted in Uganda²⁰; in another study carried out in the USA 59% of these events were reported in these departments²¹.

In conducting covariance analysis in this study, a statistically significant relationship was found between time of the last training course of ACLS with satisfactory results in theoretical and practical evaluations, which means that the more recent the intervention, the better results there will be. This agrees with the results of a study conducted by Jensen *et al.* (2009), which found that declination of knowledge in ACLS was lower when courses were conducted at 0 and 6 months, with evaluations at 6 months and 12 months, with average scores of 73, 85 and 82%, respectively²².

In relation to the years of clinical practice, it was observed in the present study that this factor influenced the evaluation results ($p < 0.05$). In the study carried out by Yang *et al.* (2012), it is mentioned that the participants who had at least half a year of clinical practice, obtained better results than those that had less time¹³.

On the contrary, there was statistically significant difference between the results and level of stress a student had. This contrasts with the study of Júnior *et al.* (2002), which shows that stress significantly affects the performance of the participant, and sleep time did not affect the results²³.

The study has several limitations. Since the qualification of the evaluations do not affect the student's final performance in the post-graduate degree, the written examination grade may not reflect the participant's knowledge. Since the research was held at Pontificia Universidad Católica de Ecuador, it is difficult to

generalize the study, taking into account that in this institution it is compulsory for graduate students to perform training in ACLS; however, in most universities in Ecuador, these are not conducted, so the level of previous knowledge will vary depending on the situation.

Conclusions

Cardiovascular diseases are included in the first 10 causes of mortality in Ecuador, which means it is necessary to perform training in the management of cardiorespiratory arrest.

Knowledge gained from courses in ACLS of post-graduate studies in Emergencies and Disasters, Anesthesiology and Critical Medicine deteriorate after 30 days in advanced cardiovascular life support. It should be emphasized that practical skills are the most affected compared with theoretical skills.

The results of this research indicate that it is necessary to carry out courses more frequently, in order to keep knowledge and skills at a level that guarantees that adequate care to patients is provided, reducing potential risk of death or disability.

Data availability

Underlying data

Figshare: Raw data for each participant. <https://doi.org/10.6084/m9.figshare.7965020.v1>¹¹.

Figshare: Data for Evaluation of the retention of skills in advanced cardiovascular life support (ACLS), following a theoretical-practical intervention in postgraduate physician students of critical areas. <https://doi.org/10.6084/m9.figshare.7844999.v1>⁷.

This project contains the following aggregated underlying data:

- Characteristics of the participants
- Performance of the participants
- Results of the evaluation
- Practical skills
- ANCOVA written
- ANCOVA practical

Extended data

Figshare: Survey used in Evaluation of the retention of skills in advanced cardiovascular life support (ACLS), following a theoretical-practical intervention in postgraduate physician students of critical areas. <https://doi.org/10.6084/m9.figshare.7848245.v1>⁹.

Figshare: Checklist for practical exam. <https://doi.org/10.6084/m9.figshare.7940606.v1>²⁴.

All data are available under the terms of the [Creative Commons Attribution 4.0 International license](#) (CC-BY 4.0)

Grant information

The author(s) declared that no grants were involved in supporting this work.

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Open Peer Review

Current Peer Review Status: ? ? ? ?

Version 1

Reviewer Report 13 September 2019

<https://doi.org/10.5256/f1000research.20405.r52806>

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Paweł Więch

Institute of Nursing and Health Sciences, Faculty of Medicine, University of Rzeszów, Rzeszów, Poland

I am grateful for the opportunity to review the manuscript presented to me. I hope that the comments in the review would be helpful in deciding whether to index the manuscript in your journal.

I believe the paper is worth considering for indexing, however requires major revision.

General comments

Abstract:

- The abbreviation **CPR** should be explained the first time it is used in the text.
- Scores for the immediate theoretical exam were 58.6% immediately after the intervention vs 40% 30 days after the intervention – in my opinion better will be: Scores for the immediate theoretical exam were 58.6% immediately after the intervention vs 40% thirty days after the intervention.

Introduction:

- A few sentences of the introduction about the need and effectiveness of resuscitation in the study group are missing. Why the study was conducted specifically among medical students? It should be explained.

Methodology:

- You used *...students of Medicine at Pontificia Universidad Católica of Ecuador* ... two times : in **Participants and study setting section** and **Theoretical-practical course section** – its more than enough.
- Mannequins and tools should be thoroughly described.
- I need much more information about your author's survey questionnaire.
- *After 30 days, the theoretical and practical evaluation was carried out once again for each of the participants* – in my opinion most of the available studies in the above scope analyse a longer period of time than 1 month.
- Whether pilot studies were carried out?

- **What was the** statistically significant?
- What was the ethical consideration?

Results:

- ... *When conducting the post-hoc test through Scheffe...* I did not see this information in the data analysis section.
- Only one Table presenting the data is insufficient.

Discussion:

- ...*Basic Life Support (BLS) program and postgraduate (BLS and ACLS Advanced Cardiovascular Life Support) training...* the abbreviations were already explained in the beginning of the article.
- ...*however, there are not many previous studies that indicate the behavior between 1 to 6 months* ... - we need to citations.

Conclusion:

- Should be in 1-2 sentence.

References:

- The record of citations should be standardised. In your references I see many lacks , eg. 15. Burkhardt JN, Glick JE, Terndrup TE: *Effect of prior cardiopulmonary resuscitation knowledge on compression performance by hospital providers. West J Emerg Med.* 2014; 15(4): 404–8. Vs. 7. Salgado Castillo MF: *Data for EVALUATION OF THE RETENTION OF SKILLS IN ADVANCED CARDIOVASCULAR LIFE SUPPORT (ACLS), FOLLOWING A THEORETICAL-PRACTICAL INTERVENTION IN POSTGRADUATE PHYSICIAN STUDENTS OF CRITICAL AREAS. figshare. Dataset.* 2019.
- I did not see similar studies form last 2-3 years. I recommend some new one¹.

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Is the work clearly and accurately presented and does it cite the current literature?

Partly

Is the study design appropriate and is the work technically sound?

Yes

Are sufficient details of methods and analysis provided to allow replication by others?

Partly

If applicable, is the statistical analysis and its interpretation appropriate?

Partly

Are all the source data underlying the results available to ensure full reproducibility?

Partly

Are the conclusions drawn adequately supported by the results?

Partly

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Emergency medicine and nursing, body composition, telemedicine

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Reviewer Report 09 September 2019

<https://doi.org/10.5256/f1000research.20405.r52805>

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Marcia A. Corvetto

Center of Experimental Surgery and Simulation, Pontifical Catholic University of Chile, Santiago, Chile

I really appreciate the opportunity to review this manuscript. The feedback written have been done with respect to the authors and with the aim to improve the manuscript. I hope to have a good reception by them. Simulation research is just starting in Latin America, so I congratulate the authors for the excellent work that they have done.

The manuscript initially looks interesting, well written and well referenced. But reading it more deeply, few concerns arises. The majority of my concerns revolve around how the manuscript was written and to have more information about methods and stats.

Methods:

1. Did the authors perform an ethical committee submission? This should be stated in this section.
2. Line 5: "Taking a heterogeneity of 50%, with a margin of error of 5% and a level of confidence of 95%, the sample was 140 students". In order to have the statistical details all together in one part of the manuscript, I would move this part to stats.
3. Ln 7: "For the selection of the sample, randomized sampling was carried out".I don't understand completely this part. How did the authors the randomization process?. The randomization was performed to assign the instructor for the assessment? I would expect a deeper explanation about how the authors did the selection of participants.
4. Ln 8: "Groups of 7 people were organized for each evaluator in a random manner, with a total of 14 participants per day, ending at the 10th day with the 140 participants".I would explain the training first and then the assessment. From my perspective methods should be written in order to be clearer for the reader.
5. Ln 41: "Theoretical standardized tools were used for evaluating the course received".I

understand that AHA assessments are standardized. But as a reader I would expect a deeper explanation about the assessment. Did the authors videotape the assessment sessions? Did they do the assessment by direct observation? Did the authors used 2 observers for the assessment?

6. Ln 50: "After 30 days, the theoretical and practical evaluation was carried out once again for each of the participants. Again, I would expect a deeper explanation about the assessment. 1 versus 2 observers? Direct observation versus videotaped? If videotaped, blinded assessment regarding first and second evaluation? Agreement calculation?

Data analysis:

1. I would state here how the authors did the sample size calculation. What difference did the authors used to calculate the sample size?
2. Ln 1: "Cohen Kappa index was initially performed to determine the concordance and standardization of the knowledge taught in the intervention". I am not clear about what type of agreement did the authors calculated with Cohen Kappa?
3. Ln 3: "The result was 0828, which indicates a high agreement between the two instructors; therefore, it was possible to continue with the study". This should be explained in results. I would use a point in the number 0.828.
4. Ln 8: "Central tendency and dispersion tests were performed, as well as Student's t-test, one-way ANOVA and ANCOVA". Regarding Students' t-test. Did the author used independent or paired measures test?

Results:

1. Ln 2: "There were statistically significant differences between the subject groups for the first theoretical test immediately after the ACLS course. It was observed that these differences were between the Emergencies and Disasters and Anesthesiology groups ($p < 0.05$), as well as between the Critical Medicine and the Anesthesiology groups ($p = 0.027$). No statistical difference was seen between the Emergencies and Disasters and Critical Medicine groups". It's difficult for me to understand the differences. Maybe to add a table would be better for the reader. The same for the second theoretical assessment.
2. Ln 16: "There was no statistically significant differences in the first practical examination between the groups when evaluating their practical skills acquired immediately after the intervention of ACLS ($p = 0.066$)". Again, maybe add a table. I would add the test that the authors did to perform the comparisons between groups.

3. Table 1: Please include the number of participants per group. Additionally, a dispersion measure should be state for each line.

Discussion:

1. Ln 36: "These findings suggest that appropriate intervals and re-training strategies should be differentiated between knowledge and skills, with reinforcement of the latter". I would discuss the idea of rethink how powerful is the intervention. I understand that ACLS protocols have been done succesfully for years. However, the mission of educators and researchers is to questioning how we are doing it, supported by this interesting new data. Maybe a 1 day course is not enough training to achieve strong competencies. A good score immediately after the course, could be explained by repetition and doesn't assure a good

achievement of competencies. Previous literature supports the idea of skill decay. But 1 month is so short from a practical perspective, that we should rethink how we should train these competencies.

Is the work clearly and accurately presented and does it cite the current literature?

Yes

Is the study design appropriate and is the work technically sound?

Yes

Are sufficient details of methods and analysis provided to allow replication by others?

Partly

If applicable, is the statistical analysis and its interpretation appropriate?

Partly

Are all the source data underlying the results available to ensure full reproducibility?

Yes

Are the conclusions drawn adequately supported by the results?

Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Simulation

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Reviewer Report 02 September 2019

<https://doi.org/10.5256/f1000research.20405.r52804>

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Eduardo Kattan

Department of Intensive Medicine, Pontifical Catholic University of Chile, Santiago, Chile

I appreciate the opportunity to revise this manuscript. In brief, the authors have performed a theoretical and practical course on CPR in postgraduate students of critical areas in Ecuador.

After finishing the course, they tested one month later the retention of students both in the theoretical and practical aspects delivered during the course. There is a significant decrease in

cognitive and skills performance, and it is further analysed according to each speciality training.

I believe this is a well-written manuscript, with clear objectives, adequate methodology and a developed discussion that addresses the relevant topics involved in CPR training and simulation training in general.

I have a few comments, including:

1. Consider including the following updated reference for delays in CPR: Bircher NG, Chan PS, Xu Y; et al. Delays in Cardiopulmonary Resuscitation, Defibrillation, and Epinephrine Administration All Decrease Survival in In-hospital Cardiac Arrest. *Anesthesiology*. 2019 Mar;130(3):414-422. doi: 10.1097/ALN.0000000000002563.¹
2. Table 1 should include N° of participants in each group, plus the standard deviation of each measurement. Even though results are expressed as a percentage, they are an average of a score of the study group, as presented in the table's title. In this sense, a dispersion value is needed to better understand the sample's distribution.
3. When mentioning the use of Students' t-test, did you refer to both independent and paired measures test? Considering that the comparison between groups are independent groups but intra-group comparison is a repeated measure test? If so, it should be specified in the methods section.
4. What happened with the students that failed to meet the minimum passing score? Are there remedial sessions or new tests performed?
5. After this study, will there be any change of conduct in your institution? What would you recommend for future versions of the course? Include more training sessions to the program? Shorten the gap between training sessions? Specific targeting of the groups that performed poorly?
6. I believe this is an interesting study, that allows to explore more in-depth the fine details of training of a complex and lifesaving skill like CPR. Indeed, this data allows to improve training programs and optimise the learning of medical trainees.

Congratulations to the authors for the work done.

References

1. Bircher NG, Chan PS, Xu Y, American Heart Association's Get With The Guidelines–Resuscitation Investigators: Delays in Cardiopulmonary Resuscitation, Defibrillation, and Epinephrine Administration All Decrease Survival in In-hospital Cardiac Arrest. *Anesthesiology*. **130** (3): 414-422
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Yes

Is the study design appropriate and is the work technically sound?

Yes

Are sufficient details of methods and analysis provided to allow replication by others?

Yes

If applicable, is the statistical analysis and its interpretation appropriate?

Partly

Are all the source data underlying the results available to ensure full reproducibility?

Yes

Are the conclusions drawn adequately supported by the results?

Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Intensive Care Medicine, Anesthesiology, Medical Education

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Reviewer Report 13 August 2019

<https://doi.org/10.5256/f1000research.20405.r52300>

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William D. Grant

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- The reference that delay of CPR leads to 10% per minute reduction in survival is from a 10 year old reference. Given the changes in CPR administration and training over the past 10 years (such as no breath CPR) is there a more up-to-date figure?
- The details of what specifically was examined are limited? What were the specific score parameters for the theoretical and for the practical sections?
- As there is no global agreement as to the standards of acceptability of homogeneity and the fact that the values are almost always determined post hoc, and the admission that this is the first study of its type, what standard was used to determine that 50% was acceptable and how was this tested to determine if it was met at the end of the study?
- Sample size is usually determined as the basis of the smallest intended group for analysis not for over-all sample size. Given that the individual critical areas samples are small this should be addressed in the limitations.

- The study is actually a repeated measures study and should be addressed as such.
- Little demographic data is presented in the text but the reader is referred to the available data to do their own determination. Table 1 of the study should be a demographics table by the three groups.
- Statistical results presentations are undergoing evolution with less emphasis being placed on p values (see recent NEJM announcements). Each statistical finding should be presented with the statistic which provides information on the likelihood of observing a specific value using a specific analysis and should include a 96% Confidence Interval estimate for each difference noted. These two pieces of information provide different information. One is the likelihood of an observed value and the other is an estimate of the magnitude of the difference between the groups. For example: "...the difference between the groups was 15.7 [t=3.67,df 2, p<0.05 95%CI +/- 3.6],...."
- Table 1 should include N's for each group especially if the numbers changed from post test to follow-up.
- There is information on the field of learning and practice effect including that learning occurs in plateau fashion. Students show learning growth, reach a plateau even while practising, then gain again in step increase manner. So it is not just the frequency of practice but also the tracking of students' skills to identify when they have reached a plateau and need to be pushed through it to reach proficiency.
- The study focuses on pre-post-follow-up differences. Unless it was missing in reading there was no measurement against a minimally acceptable standard. For example in Table 1 Emergencies and Disasters had a post practical score of 79%. Does this mean that their score is so bad that they should be prevented from administering CPR? What is the acceptable standard?

Thank you for the opportunity to review this article.

Is the work clearly and accurately presented and does it cite the current literature?

Partly

Is the study design appropriate and is the work technically sound?

Yes

Are sufficient details of methods and analysis provided to allow replication by others?

Yes

If applicable, is the statistical analysis and its interpretation appropriate?

Partly

Are all the source data underlying the results available to ensure full reproducibility?

Yes

Are the conclusions drawn adequately supported by the results?

Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Statistics, clinical research design and implementation, emergency medicine

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

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