Evaluating the retention of skills in postgraduate physician students following a theoretical-practical course in Advanced Cardiovascular Life Support [version 1; peer review: 1 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 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
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
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 women. 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 1000,000. 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%). Just in Ecuador, the number of deaths from heart disease in 2010 was 11992 (51.68% in men and 48.32% in women).

Mortality from arterial hypertension, cerebrovascular disease and diabetes mellitus has increased in general; 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.

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 de 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) 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 instructors, 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.

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 instructors; 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. 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).

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 \(^6,12\), 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 time \(^9,13-16\), and also that the results of theoretical examinations are not good predictors of practical evaluation results \(^7\). 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>
<thead>
<tr>
<th>Evaluation</th>
<th>Emergencies and Disasters (%)</th>
<th>Anesthesiology (%)</th>
<th>Critical Medicine (%)</th>
<th>Total (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theoretical 1</td>
<td>86.36</td>
<td>77</td>
<td>84</td>
<td>83.43</td>
</tr>
<tr>
<td>Theoretical 2</td>
<td>79.57</td>
<td>68.86</td>
<td>76.86</td>
<td>76.21</td>
</tr>
<tr>
<td>Practical 1</td>
<td>93.65</td>
<td>90.47</td>
<td>97.46</td>
<td>93.81</td>
</tr>
<tr>
<td>Practical 2</td>
<td>79.20</td>
<td>64.75</td>
<td>79.68</td>
<td>75.71</td>
</tr>
</tbody>
</table>
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 Areas. The reason for having less retention in this group can be explained by several factors, including the low incidence of patients with cardiopulmonary 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 10000. 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 Uganda; in another study carried out in the USA 59% of these events were reported in these departments.

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%, respectively. 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 time.

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 of 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 cardiopulmonary 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


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

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.
References

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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?
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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