Effect of formal advanced cardiovascular life support training with high-fidelity mannequins on knowledge and confidence of third-year PharmD students

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Abstract

Introduction: Logistical and financial barriers have traditionally prevented formal American Heart Association (AHA) advanced cardiovascular life support (ACLS) training from being taught in the core Doctor of Pharmacy (PharmD) curriculum. The objective of this study was to determine the benefit of ACLS training on knowledge and confidence of PharmD students.

Methods: Two modes of ACLS instruction were administered: (1) didactic lecture followed by skills assessment using low-fidelity simulation taught to all 3rd year PharmD students (n=133) and (2) formal AHA ACLS training offered to a subset of students (n=24). Three assessments were administered: a pre- and post-test of all students assessing knowledge and confidence of ACLS and an additional post-test after completing formal AHA ACLS training. Changes in knowledge and confidence were compared with the Chi-squared and Mann Whitney U tests, as appropriate.

Results: Formal ACLS certification resulted in increased knowledge of ACLS (75.6% vs 85%, p=0.045). Student confidence also improved after ACLS certification, with identification as "expert" increasing from 1 to 3 areas (p=0.004) and self-ratings of novice, advanced beginner, and competent all decreasing, indicating a shift towards higher confidence levels.

Conclusion: Formal AHA training with high-fidelity mannequins improved pharmacy student knowledge and confidence of ACLS fundamentals.

Keywords: simulation; pharmacy; education; critical care; advanced cardiovascular life support
Introduction

Pharmacy practice training must prepare trainees to perform in an interprofessional patient care environment. In particular, emergency and critical care pharmacist services as part of an interprofessional patient care team have been repeatedly shown to improve outcomes (Bauer and Kane-Gill, 2016; Erstad et al., 2011; Rudis and Brandl, 2000; Hammond et al., 2019; Lee et al., 2019). These services frequently include participation on the cardiopulmonary resuscitation team, where having a pharmacist present has been shown to reduce mortality (Bond and Raehl, 2007). Notably, the Society of Critical Care Medicine and the American College of Clinical Pharmacy position paper on critical care pharmacy services identify pharmacist certification in advanced cardiovascular life support (ACLS) and 24/7 response to in-hospital resuscitation events as “desirable” activities (Rudis and Brandl, 2000).

ACLS training supports student development of the core entrustable professional activities (EPAs) outlined by the American Association of Colleges of Pharmacy (AACP), with the goal of EPAs being to develop “practice-ready” pharmacists in the Doctor of Pharmacy (PharmD) curriculum. Previous research demonstrated that incorporation of ACLS fundamentals into the third-year core curriculum improved knowledge and perception of pharmacy students (Newsome et al., 2018).

While incorporation of ACLS fundamentals into the third-year core curriculum proved successful, formal American Heart Association (AHA) ACLS certification may offer further benefits for PharmD students including both an enhanced training experience and career-building certification experience. The training experience may be enhanced by review of key material in a small teaching environment. Specifically, repetition of basic life support (BLS) and ACLS material is important for long-term retention (Sutton et al., 2011). Further, AHA certification requires a set instructor to student ratio to facilitate high-fidelity mannequin and simulation training and an individualized learning experience for students, potentially enhancing learning. Finally, an advanced certification from a reputable organization may help differentiate students in an increasingly competitive market for jobs and post-graduate training. Despite advantages, formal AHA ACLS training has not been incorporated into the core curriculum due to the cost associated with training and logistical barriers of training 140 students in instructor to student ratios of 1:8 or less.

This study sought to identify the impact of formalized AHA ACLS certification on PharmD students’ knowledge and confidence and to compare benefits of using this technique to traditional classroom methods used in the core curriculum.

Methods

At the University of Georgia (UGA) College of Pharmacy, two modes of ACLS instruction were assessed through two different groups/courses: core curriculum (group 1) and AHA certification (group 2).

Course design

ACLS principles are taught to all third-year students as part of the core curriculum in the Applied Pharmacy Practice II (APP II) course. ACLS training in this course consists of a two-hour didactic lecture followed by a two-hour skills-based class. In the skills-based class, smaller groups of 10-18 students used low-fidelity cardiopulmonary resuscitation (CPR) mannequins, trainer automated external defibrillators (AEDs), and mock code drugs to practice ACLS in a simulated code setting.

Students enrolled in the critical care elective at UGA were offered the optional opportunity to receive AHA ACLS
certification. The students that chose to participate were required to prepare for the certification ahead of time and participate in a live two-day training class outside of regularly scheduled class time (Table 1). Students were asked to complete the AHA Precourse Preparation checklist prior to the live portion of ACLS training, including CPR/AED competency, understanding the 10 cases in the AHA ACLS provider manual, understanding the ACLS algorithms in the AHA ACLS provider manual, and the ACLS Precourse Self-Assessment on ACLS ECGs and Pharmacology on the ACLS Student website. During the AHA training, students were provided with interactive training using high-fidelity mannequins that provided real-world ACLS experience using a learner-focused, active-learning platform. Students were assessed on their ability to lead a megacode scenario with the high-fidelity mannequin and complete a standardized written assessment provided by the AHA. The megacode is a standard component of certification and involves each student leading a team through a simulation that evolves from an unstable arrhythmia to pulseless shockable and non-shockable rhythms. The recommended instructor to student ratio was 1:8. Students completing all portions of the course and passing the AHA exam with a score of 80% or higher received an AHA ACLS certification card. Students who completed these activities were included in group 2 of the present analysis.

Table 1. Design of ACLS instruction

|                                      | Core curriculum                                                                 | AHA certification course                                                                 |
|--------------------------------------|---------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------|
| Preparation work before class        | No preparation work required. Optional preparational materials included:         | AHA Precourse Preparation Checklist                                                      |
|                                      | • PowerPoint prepared by course instructors                                     | • CPR/AED Competency                                                                     |
|                                      | • Copies of ACLS algorithms provided for pre-class review                         | • 10 cases in AHA ACLS provider manual                                                   |
|                                      |                                                                                 | • ACLS algorithms in AHA ACLS provider manual                                             |
|                                      |                                                                                 | • ACLS Precourse Self-Assessment on ACLS ECGs and Pharmacology on the ACLS Student website |
| Live teaching component              | 4 hours                                                                         | 9 hours                                                                                  |
|                                      | • 2-hour didactic portion                                                        | • 5-hour didactic portion                                                                 |
|                                      | • 2-hour skill based portion                                                     | • 4-hours skill based portion                                                            |
| Mannequin                            | Low-fidelity                                                                    | High-fidelity                                                                            |
| Instructor to student ratio          | (1:10-18)                                                                       | (1:8)                                                                                   |
| Megacode simulation in skills portion of class | Not utilized                                                               | Utilized                                                                                 |
| Standard written assessment provided by AHA | Not utilized                                                                | Utilized                                                                                 |
| Assessment of ability to lead megacode | Not performed                                                               | Performed                                                                                |

Evaluation and Assessment

Students in both groups were assessed in the following areas regarding ACLS training: confidence, knowledge and skills. To assess confidence and knowledge, all third-year students completed a 10 item pre-instruction assessment prior to receiving any ACLS instruction. The assessment included 15 questions assessing students’ perceived confidence in ACLS knowledge and skills (Supplementary File 1) as well as 10 questions assessing students’ knowledge (Supplementary File 2). Confidence was assessed using the Dreyfus model wherein questions asked students to rate themselves as novice, advanced beginner, competent, proficient, or expert (Persky and Robinson, 2017). Knowledge was assessed through ACLS-related content questions. A question bank of 20 knowledge
questions was developed that aligned with objectives from both the core curriculum and the AHA certification course, and 10 questions were randomly generated from the bank for each student (Table 2).

**Table 2. Objectives in ACLS instruction**

| Core Curriculum                                                                 | AHA course |
|---------------------------------------------------------------------------------|------------|
| Formulate a treatment plan for patients with cardiovascular emergencies utilizing the ACLS algorithms | X          |
| Identify the role of the pharmacist on an ACLS team                              | X          |
| Perform prompt-high quality BLS, including prioritizing early chest compressions and integrating early automatic external defibrillator use (AED) | X          |
| Recognize respiratory arrest                                                     | X          |
| Perform early management of respiratory arrest                                   | X          |
| Recognize bradyarrythmias and tachyarrythmias that may result in cardiac arrest or complicate resuscitation outcome | X          |
| Discuss early recognition and management of ACS, including appropriate disposition | X          |
| Discuss early recognition and management of stroke, including appropriate disposition | X          |
| Apply the Basic Life Support (BLS), Primary, and Secondary Assessment sequences for a systematic evaluation of adult patients | X          |
| Perform early management of cardiac arrest until termination of resuscitation or transfer of care, including immediate post-cardiac arrest care | X          |
| Evaluate resuscitative efforts during a cardiac arrest through continuous assessment of cardiopulmonary resuscitation (CPR) quality, monitoring the patient's physiologic response, and delivering real time feedback to the team | X          |
| Model effective communication as a member or leader of a high-performance team    | X          |
| Recognize the impact of team dynamics on overall team performance                | X          |
| Discuss how the use of a rapid response team or medical emergency team may improve patient outcomes | X          |
| Deliver systems of care                                                          | X          |

AHA – American Heart Association

After completing all components of ACLS instruction for the respective group, students were asked to complete a post-instruction assessment. This assessment contained the same perception questions assessing confidence and the same bank of knowledge questions as the pre-instruction assessment. The bank of knowledge questions was used so that the assessment of knowledge was not skewed by students taking the survey on more than one occasion. All third-year students completed the assessment before and after the core curriculum ACLS instruction in March 2019 (group 1). Students completing the AHA certification course in May 2019 were given the assessment a third time, after completing the AHA ACLS training (group 2).

**Data analysis and interpretation**

All statistical analyses were conducted using SPSS® Statistics Version 26. Nonparametric tests were used to evaluate student confidence and knowledge related to ACLS. For continuous variables, including assessment of confidence and overall score on knowledge questions, the two groups were compared using the Mann Whitney U test. Categorical variables (e.g. individual knowledge-based questions reported as proportion answering correctly)
were compared using the Chi-squared test. For all statistical analyses, an alpha of 0.05 was considered significant. The baseline pre-course assessment that was conducted prior to any ACLS training in the core curriculum is labeled "baseline". The assessment given after the APP II class in the core curriculum is labeled "post core curriculum". For the students participating in the AHA ACLS formal training, their post core curriculum scores were used as the baseline and were then compared to scores obtained on the assessment given after the AHA training, labeled "post AHA".

**Results/Analysis**

Of the 132 students enrolled in the core curriculum, 132 (100%) completed the pre- and post-class assessments. All 24 (100%) of the students that chose to participate in the AHA ACLS certification course completed the post assessment after completion of the course. Table 3 shows selected demographics of the two groups. Of note, a larger percentage of students in the AHA ACLS certification group indicated residency training as their post-graduate plan than when all P3 students were polled (63% vs 40%).

| Table 3. Demographic characteristics of students receiving ACLS instruction |
|--------------------------------------------------|-----------------|---------|
| Gender                                      | Core Curriculum (n=132) | AHA (n=24) |
| Female                                      | 49 (37%)         | 12 (50%)   |
| Male                                        | 82 (62%)         | 12 (50%)   |
| Prefer not to Answer                        | 1 (1%)           | 0 (0%)     |
| Age                                         |                  |          |
| 20 – 24 yrs                                 | 86 (65%)         | 18 (75%)   |
| 25 – 29 yrs                                 | 38 (29%)         | 5 (21%)    |
| 30 – 39 yrs                                 | 5 (4%)           | 1 (4%)     |
| 40 – 49 yrs                                 | 3 (2%)           | 0 (0%)     |
| Other Degrees Held                          |                  |          |
| Bachelor’s                                  | 71 (54%)         | 10 (42%)   |
| Master’s                                    | 19 (14%)         | 2 (8%)     |
| Other professional degree                   | 1 (1%)           | 0 (0%)     |
| Post-graduate plans                         |                  |          |
| Community pharmacy job                      | 38 (29%)         | 2 (8%)     |
| Hospital pharmacy job                       | 19 (14%)         | 4 (17%)    |
| Other pharmacy job                          | 13 (10%)         | 2 (8%)     |
| Residency training                          | 53 (40%)         | 15 (63%)   |
| Fellowship training                         | 9 (7%)           | 1 (4%)     |

AHA – American Heart Association

The difference in confidence and knowledge before and after ACLS training in the core curriculum has been reported previously (Newsome et al., 2018). There were significant reductions in self-perceived ratings of novice and advanced beginner (p<0.001 for each), while there were significant increases in the ratings of competent, proficient, and expert (p<0.0001 for each). Student knowledge increased significantly as well, with the mean overall score on the knowledge questions increasing by approximately 20% (p<0.001).

The responses on the post AHA ACLS assessment were compared to the post core curriculum test results from the same students (Table 4). Self-perceived ratings of novice, advanced beginner, and competent all decreased numerically, with a statistically significant decrease in the advanced beginner category (average number of responses 3.2 vs 0.96 [p=0.043]). Proficient and expert ratings both increased, with a significant increase in the expert category.
(average number of expert responses 1.0 vs 3.0 [p=0.004]). Overall score on the knowledge portion of the exam also increased significantly after AHA ACLS certification, with the mean score increasing from 75.6% to 85% (p=0.045).

Table 4. Change in Confidence after AHA ACLS Certification

|                    | Post Core Curriculum | Post AHA     | p-value<sup>2</sup> |
|--------------------|----------------------|--------------|---------------------|
| Perceptions<sup>1</sup> |                      |              |                     |
| Novice             | 0.33 ± 1.3           | 0.17 ± 0.82  | 0.480               |
| Advanced Beginner  | 3.2 ± 3.7            | 0.96 ± 1.8   | 0.043               |
| Competent          | 6.5 ± 3.8            | 4.4 ± 3.3    | 0.076               |
| Proficient         | 4.1 ± 3.5            | 6.1 ± 3.3    | 0.146               |
| Expert             | 1.0 ± 1.7            | 3.0 ± 3.1    | 0.004               |
| Knowledge          |                      |              |                     |
| Overall Score      | 75.6 ± 19.8          | 85.0 ± 11.0  | 0.045               |

<sup>1</sup>Represents the average number of responses in a given category in the post core curriculum survey compared to the post AHA ACLS certification course survey
<sup>2</sup>comparison between post core curriculum and post AHA surveys

Table 5 displays changes in confidence for individual questions assessed. After ACLS instruction in the core curriculum, there was a significant improvement in each individual question in regards to perceived confidence (p<0.001). However, after completing AHA ACLS certification, some individual questions of confidence significantly improved, while others did not. For example, confidence question 9 "I know which medications to use for different cardiac arrhythmias" improved from a mean rating of 3.0 to a mean rating of 3.8 (p=0.001). Perception question 10 states "I know the doses of medications to use for different cardiac arrhythmias", with the mean rating improving from 2.9 to 4.1 (p <0.001). However, question 7 "I am able to perform adequate chest compressions" and question 8 "I know when to choose synchronized cardioversion or defibrillation" did not improve significantly (3.9 to 4.2 [p=0.605], and 3.1 to 3.7 [p=0.083], respectively). Supplementary File 1 lists all of the questions used to assess confidence in the assessment.

Table 5. Change in confidence for individual questions after the core curriculum and after AHA ACLS training

|          | Baseline     | Post core curriculum | Change in core curriculum<sup>1</sup> | p-value<sup>2</sup> | Post AHA     | Change in AHA<sup>3</sup> | p-value<sup>4</sup> |
|----------|--------------|----------------------|---------------------------------------|---------------------|--------------|--------------------------|---------------------|
| Confidence<sup>1</sup> | 2.5 ± 0.95   | 3.3 ± 0.80           | 0.8 ± 1.2                             | <0.001  | 4.0 ± 0.62 | 0.9 ± 1.44               | 0.009               |
| P2       | 2.3 ± 0.88   | 3.4 ± 0.77           | 1.0 ± 1.1                             | <0.001  | 3.7 ± 0.75 | 0.46 ± 1.3               | 0.358               |
| P3       | 1.8 ± 0.73   | 2.9 ± 0.73           | 1.1 ± 1.0                             | <0.001  | 3.0 ± 0.81 | 0.17 ± 1.3               | 0.480               |
| P4       | 1.7 ± 0.79   | 2.9 ± 0.79           | 1.1 ± 1.1                             | <0.001  | 3.7 ± 0.87 | 0.75 ± 1.4               | 0.038               |
| P5       | 2.4 ± 1.1    | 3.5 ± 0.90           | 0.99 ± 1.2                            | <0.001  | 4.1 ± 0.90 | 0.71 ± 1.4               | 0.029               |
| P6       | 2.7 ± 1.2    | 4.0 ± 0.89           | 1.3 ± 1.4                             | <0.001  | 4.5 ± 0.66 | 0.79 ± 1.6               | 0.047               |
| P7       | 3.0 ± 1.0    | 3.9 ± 0.82           | 0.85 ± 1.2                            | <0.001  | 4.2 ± 0.76 | 0.46 ± 1.5               | 0.605               |
| P8       | 1.9 ± 0.95   | 3.1 ± 0.84           | 1.2 ± 1.2                             | <0.001  | 3.7 ± 0.83 | 0.58 ± 1.6               | 0.083               |
| P9       | 1.8 ± 0.77   | 3.0 ± 0.78           | 1.2 ± 1.1                             | <0.001  | 3.8 ± 0.85 | 0.83 ± 1.4               | 0.001               |
| P10      | 1.5 ± 0.66   | 2.9 ± 0.86           | 1.4 ± 1.0                             | <0.001  | 4.1 ± 0.79 | 1.1 ± 1.5               | <0.001              |
| P11      | 1.7 ± 0.82   | 2.9 ± 0.79           | 1.2 ± 1.2                             | <0.001  | 3.5 ± 0.79 | 0.63 ± 1.5               | 0.009               |
Discussion

Formal AHA ACLS certification resulted in significantly higher scores on knowledge-based assessments. Additionally, formal AHA ACLS certification significantly increased the amount of responses in the "expert" category. Responses in the novice, advanced beginner, and competent categories all decreased, while the proficient and expert categories increased. Of the individual questions measuring confidence, nine out of fifteen questions significantly improved. The remaining six questions all increased from confidence levels measured immediately after the APP II in the core curriculum but did not reach statistical significance. This indicates an overall shift towards responses that indicate higher levels of confidence instilled by the formal AHA ACLS certification. While previous studies have demonstrated that teaching ACLS improves knowledge (Newsome et al., 2018; Eng et al., 2014), this study is the first to directly compare two teaching modalities within the PharmD curriculum.

Students demonstrated improved scores in knowledge and confidence under the AHA ACLS method of instruction. This observation is in line with Eng et al. who evaluated high-fidelity simulation ACLS training with pharmacy students and observed significantly improved scores in knowledge, confidence, and skills (Eng et al., 2014). High fidelity simulation has shown to improve knowledge and satisfaction with training significantly over traditional training in the medical student population as well (Lo et al., 2011). A previous meta-analysis showed that high fidelity mannequins showed moderate benefit in skill performance at course conclusion. Differing from the present study, this meta-analysis observed no benefit for knowledge at the course conclusion (Cheng et al., 2015). This difference may be due to the fact that the students in the AHA class were also seeing the course material for a second time in addition to incorporation of high fidelity mannequins.

Improved scores in the AHA ACLS group may reflect the benefit of repetition of ACLS training over time. A previous study by Bingham et al. included both students who had been exposed to prior ACLS training and students who had not been exposed to ACLS training and observed that pharmacy students with prior ACLS experience demonstrated trends toward superiority in knowledge and skills over students with no prior experience in a simulation environment with high fidelity mannequins (Bingham et al., 2015). Similarly, a study by Ko et al. examined the difference between a traditional two day ACLS course with low-fidelity mannequins versus a modified ACLS course over the period of 2 weeks with high fidelity mannequins and an immersive simulation experience. Higher performance scores and confidence was observed among the students in the modified course (Ko et al., 2011). A meta-analysis on CPR skills retention over time showed inconclusive results about the effect of high-fidelity mannequins on long-term knowledge retention though also stating that "knowledge booster sessions" were helpful for retention of ACLS knowledge over time (Au et al., 2019).

Further, other studies suggest pharmacy students are more satisfied and perform better after being placed in "hands-on" simulation experiences. Davis et al. observed that pharmacy students were significantly more satisfied with high fidelity simulation ACLS training over classroom training alone (Davis et al., 2013). Another study showed increased
student competency and confidence when students were placed in a high-fidelity patient simulation with diabetic ketoacidosis and thyroid storm cases (Lee Chin et al., 2014). Thus, students may be more satisfied with hands-on experiences, and this satisfaction may lead to higher engagement throughout the learning process, also contributing to a higher confidence and performance score after AHA ACLS training.

Additional certifications also serve as a form of a tangible reward for pharmacy students. Tangible rewards (such as higher grades) tend to motivate students as compared to intangible incentives (e.g., praise from a teacher) (Morris and McClurg, 2014). The AHA ACLS certificate was presented as a “reward” to pharmacy students in the way that it was an additional certification for their curriculum vitae (CV) and might impress future employers. This set-up may have led to the students being more engaged to obtain their reward (i.e., ACLS certification) and the potential to improve themselves professionally. Further, pharmacy students are willing to utilize extra time and effort for tasks that are perceived as beneficial and applicable to the “real world.” Indeed, Peripelkin found that the re-creating of a pharmacy management class to be more realistic and case-based was met with enthusiasm from pharmacy students, despite requiring additional out of class work (Perepelkin, 2012). Similarly, though the AHA certification takes additional time and effort for students, this certification may be something they see as useful in their future career.

This study has several limitations. Notably, the single-center, observational design limits causal inference. Further, some crossover between groups was present. All the students in the post AHA ACLS certification had also completed the APP II class in the core curriculum, so difficulty exists in differentiating if the benefit in confidence is from ACLS certification with high fidelity models, repetition of the material, or both. There could also be selection bias, as all students were enrolled in the required APP II course, but only select students chose to enroll in the elective AHA ACLS certification course. Although this study included a single center, external validity should be well preserved due to the strict guidelines for instruction set forth by the formal AHA ACLS training. Long-term retention was not assessed in this study, which may be a major impetus to use high-fidelity mannequins and formalized AHA ACLS training in the PharmD curriculum.

**Conclusion**

While pre/post-instruction studies naturally find a benefit to nearly all forms of instruction, this study took a novel approach by comparing two methods of ACLS instruction. Students participating in formalized AHA ACLS training scored higher on knowledge-based ACLS questions and demonstrated higher levels of confidence in ACLS related skills compared to students completing ACLS training in a more traditional format in the core curriculum. The small class size, use of high fidelity simulation, and hands-on instruction provided by AHA training may have contributed to this benefit. These new findings suggest formalized AHA ACLS training should be considered for optimal training of student pharmacists in the core curriculum. Future directions should examine the effect of high-fidelity mannequins and repetition of training on long-term retention of ACLS skills.

**Take Home Messages**

- Two modes of ACLS instruction were administered to PharmD students.
- Confidence and knowledge were assessed before and after each method of instruction.
- Formal American Heart Association training had the greatest impact on performance.
- High-fidelity mannequin simulation was a useful tool for increasing student confidence.
Notes On Contributors

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Appendices

None.

Declarations

The author has declared that there are no conflicts of interest.

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Ethics Statement

Study was determined to be exempt research by the University of Georgia Institutional Review Board under the IRB ID: MOD00007863.

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