INSTRUCTIONAL DESIGN AND ASSESSMENT

Pharmacy Students' Retention of Knowledge and Skills Following Training in Automated External Defibrillator Use

Karen Birckelbaw Kopacek, BPharm, Anna Legreid Dopp, PharmD,^a John M. Dopp, PharmD,^a Orly Vardeny, PharmD,^a and J. Jason Sims, PharmD^b

^aUniversity of Wisconsin School of Pharmacy, Madison, Wisconsin

^bMedtronic, Inc., Mounds View, Minnesota

Objectives. To assess pharmacy students' retention of knowledge about appropriate automated external defibrillator use and counseling points following didactic training and simulated experience.

Design. Following a lecture on sudden cardiac arrest and automated external defibrillator use, second-year doctor of pharmacy (PharmD) students were assessed on their ability to perform basic life support and deliver a shock at baseline, 3 weeks, and 4 months. Students completed a questionnaire to evaluate recall of counseling points for laypeople/the public.

Assessment. Mean time to shock delivery at baseline was 74 ± 25 seconds, which improved significantly at 3 weeks (50 ± 17 seconds, $p < 0.001$) and was maintained at 4 months (47 ± 18 seconds, $p < 0.001$). Recall of all signs and symptoms of sudden cardiac arrest and automated external defibrillator counseling points was diminished after 4 months.

Conclusion. Pharmacy students can use automated external defibrillators to quickly deliver a shock and are able to retain this ability after 4 months. Refresher training/courses will be required to improve students' retention of automated external defibrillator counseling points to ensure their ability to deliver appropriate patient education.

Keywords: cardiopulmonary resuscitation (CPR), automated external defibrillator (AED), cardiology, assessment, simulation

INTRODUCTION

Approximately 295,000 Americans die annually from sudden cardiac arrest and the majority of these cases are caused by ventricular tachycardia or fibrillation.¹ Early defibrillation of sudden cardiac arrest improves the patient's chance of survival. If not performed, the victim's chance for survival decreases approximately 10% for every 1 minute of delay.¹⁻⁴ Despite access to certified training programs and increased availability of automated external defibrillators (AED) in public places, the incidence of bystander cardiopulmonary resuscitation (CPR) and defibrillation for victims of out-of-hospital cardiac arrest is low.^{5,6} Unfortunately, almost 80% of sudden cardiac arrest occur in residential settings where an automated external defibrillator may not be available and timely emergency medical services can be challenging.⁷ One automated external defibrillator has received approval for over-the-counter sales in the United States (HeartStart OnSite Defibrillator, Philips

Medical Systems, Andover, MA) and is intended for placement in the homes of patients at high risk for sudden cardiac arrest. However, there are no training requirements prior to purchasing this device.

Pharmacists are in a unique position to provide automated external defibrillator counseling of non-medical laypersons to ensure proper and safe use. Pharmacists routinely educate patients on the use and maintenance of common over-the-counter medical devices like blood glucose meters and blood pressure monitors. Since automated external defibrillators are now available for purchase, a pharmacist who sells them for home use should be competent in the knowledge and skills necessary to provide support and training of patients and family members. As automated external defibrillators become more available to consumers, and should the 2010 International Liaison Committee on Resuscitation (ILCOR) continue to place a strong emphasis on early access to defibrillation,⁸ pharmacists will be positioned to act as sudden cardiac arrest public service practitioners. The pharmacy profession should recognize that counseling laypersons purchasing an automated external defibrillator is a professional responsibility and this education provided by pharmacists reinforces previous training the layperson has

Corresponding Author: Karen Birckelbaw Kopacek, University of Wisconsin School of Pharmacy 1017 Rennebohm Hall 777 Highland Avenue Madison, Wisconsin 53705. Phone: 608-265-8922. Fax: 608-265-5421 E-mail: kjkopacek@pharmacy.wisc.edu

received from other sources. The first step to meeting this public health obligation is pharmacist training and education, which begins by incorporating this topic into the pharmacy curriculum.

Requiring doctor of pharmacy (PharmD) students to become competent in the use and maintenance of automated external defibrillators is supported by the Center for Advancement of Pharmacy Education (CAPE) educational outcomes. These standards recommend that pharmacy students become proficient in educating patients and caregivers on the proper use of medical goods and devices.⁹ This includes demonstrating the use of medical devices to ensure effective home use and communicating important maintenance and storage information. The 2007 Accreditation Council for Pharmacy Education (ACPE) Standards and Guidelines also address the role of pharmacy students in promoting health improvement and wellness in cooperation with patients and at-risk populations.¹⁰ To ensure the availability of effective public health services, these standards recommend that students maintain professional competency by identifying emerging products and services that may affect the efficacy of disease prevention services in order to update existing services or implement new ones. We consider the ability to deliver a defibrillation shock and knowing how to care for an automated external defibrillator to be an emerging public health skill for pharmacy students and pharmacists that will ultimately improve the health and wellness of patients at risk for sudden cardiac arrest.

Multiple studies have demonstrated that primary school,¹¹ high school,¹² medical,^{13,14} and nursing students^{15,16} can be trained to successfully deliver a shock to a patient/subject using an automated external defibrillator. To our knowledge, no study of training pharmacy students in this area has been conducted. The purpose of this study was to assess pharmacy students' ability to deliver a shock within 90 seconds during a simulated out-of-hospital cardiac arrest and their ability to teach laypersons in the care and use of an automated external defibrillator. Then, the retention of this knowledge and skill was assessed at 3 weeks and again at 4 months after training.

DESIGN

One hundred twenty-four second-year PharmD students at the University of Wisconsin School of Pharmacy were invited to participate in the study. Participants were informed that their knowledge and performance would be evaluated and used for research purposes and they were given the option to exclude their individual data from the final study analysis. All experimental procedures were approved by the University of Wisconsin Educational Institutional Review Board for Human Investigation, and written informed consent was obtained from all subjects prior to participation.

Pharmacy students attending the University of Wisconsin are required to become certified and remain current in basic life support, which includes performing CPR and using an automated external defibrillator. For many students, initial certification is completed at the beginning of the first year of pharmacy school.

Second-year students were required to attend a lecture on sudden cardiac arrest and automated external defibrillator use as part of a cardiovascular pharmacotherapy course. Prior to attending the lecture, students completed a written self-assessment survey to determine baseline skills and perceived confidence in performing basic life support. Counseling points and correct steps to using an automated external defibrillator were discussed during the lecture and a training video from the Heartsaver AED Course (Laerdal Medical Corporation, Wappingers Falls, NY) was shown.

Within 1 week of the lecture, individual students participated in a simulated out-of-hospital cardiac arrest using an automated external defibrillator trainer and manikin. The Little Anne manikin (Laerdal Medical Corporation, Wappingers Falls, NY) was used for the simulation. Each manikin was positioned in a chair and dressed with a t-shirt to provide a common barrier to electrode pad placement. The LifePak 500T AED Trainer (Medtronic Emergency Response Systems, Inc., Redmond, WA) was used for the duration of the study. The self-adhesive electrode pads used for training included a diagram to illustrate correct placement on the chest. Faculty members and third-year PharmD students certified in basic life support or advanced cardiac life support were recruited to participate as assessors. Students were read the following statement at the start of each simulation: "While rushing to your gate at the airport, you witness someone who collapses. No one in the area responds so you approach the victim to assess him and perform CPR as necessary." The assessor was allowed to obtain the automated external defibrillator when requested by the student, but could not participate in 2-person CPR or answer questions. After automated external defibrillator arrival, the student was required to turn on the automated external defibrillator and follow voice prompts to connect the electrodes to the unit, place the pads on the victim's chest, and clear the victim to analyze the rhythm. The automated external defibrillator trainers were pre-programmed to deliver one shock upon detection of a shockable rhythm, after which the automated external defibrillator voice prompt advised the user to continue CPR. Each step performed by the student was recorded on a data collection form and the time (in seconds) when the automated external defibrillator was turned on and the shock delivered was measured using a stopwatch. Our data collection form (available upon request from authors) was adapted from the 13 aspects of assessment used by de Vries

et al during automated external defibrillator training of police officers in Amsterdam.¹⁷ The simulation was stopped by the assessor after the student resumed CPR. The assessor provided immediate feedback to the student on his/her performance, indicating the time to shock and reinforcing the correct steps to performing basic life support.

Students then completed the same written survey instrument again to determine skills and assess confidence with using an automated external defibrillator. Students were also given an open-ended questionnaire designed by the study team to evaluate automated external defibrillator care and use. Students were asked to list common signs and symptoms of sudden cardiac arrest (sudden loss of responsiveness, syncope, abnormal breathing, racing heartbeat, dizziness, and chest pain), provide details for proper maintenance (check battery expiration, keep unit clean, evaluate for cracks in device and electrode wires), and list 5 special situations that require additional actions/considerations before placing electrode pads and delivering a shock (remove patient from water/dry chest; remove excess chest hair; remove transdermal medication patches; place electrodes one inch from an implanted device; and follow guidelines for automated external defibrillator use in children).

After initial training, all students were required to repeat the same out-of-hospital cardiac arrest simulation and written survey at 3 weeks and again at 4 months to assess knowledge and skill retention. Assessors recorded information using the same data collection tool and students were again debriefed on basic life support performance after the simulation. While students received feedback on basic life support techniques during training and after each testing point, no feedback related to their performance on correctly identifying the signs and symptoms of sudden cardiac arrest or the care and use of an automated external defibrillator was provided by the assessors.

EVALUATION AND ASSESSMENT

Mean time to successful shock delivery and self-rating of automated external defibrillator competence between baseline and the 2 follow-up time points were compared

using a Wilcoxon rank sum test. Percentage of students who successfully delivered a shock within 90 seconds was compared between baseline and the 2 follow-up time points using a McNemar's test for paired analysis. Frequencies of correctly identifying essential counseling points related to automated external defibrillator and correctly performing competency components were compared using chi-square tests or Fisher exact tests where appropriate. A p value < 0.05 was considered significant.

One hundred three students (83%) consented to participate in the study. The most frequently reported length of time from completion of basic life support training to entry into the study was 18-24 months (48.5% of participants). At study commencement, 7 subjects had witnessed CPR being performed and 1 subject had previously performed CPR. The mean self-rated knowledge of basic life support at baseline was 2.9 ± 0.6 (1 = very good knowledge, 2 = good knowledge, 3 = sufficient knowledge, 4 = insufficient knowledge). Self-rated knowledge of basic life support significantly improved at 3 weeks (2.2 ± 0.6 , $p < 0.001$) and at 4 months (2.3 ± 0.6 ; $p < 0.001$) compared to baseline. The students' mean self-rated fear of making a mistake while performing basic life support at baseline was 2.5 ± 0.8 (1 = not at all, 2 = a little, 3 = quite, 4 = very much). Subjects' fear of making a mistake significantly decreased from baseline at both 3 weeks (2.1 ± 0.5 , $p < 0.001$) and 4 months (2.1 ± 0.5 , $p < 0.001$).

The majority of students were able to correctly perform basic life support competency skills at baseline, with the exception of (1) clearing the victim to allow the automated external defibrillator to analyze rhythm, and (2) clearing the area around the victim prior to shock delivery (Table 1). Compared to baseline, the percentage of students successfully performing all competency skills improved at 3 weeks and remained the same at 4 months, with the exception of electrode pad placement. The percentage of students who could correctly position the electrodes on the manikin at 3 weeks significantly decreased from baseline ($p = 0.007$) and remained lower than baseline at 4 months ($p = 0.08$).

Table 1. Frequency With Which Pharmacy Students Correctly Performed Basic Life Support Competency Skills, %

Competency Skill	Baseline (n = 103)	3 Weeks (n = 103)	3 Weeks vs Baseline, p	4 Months (n = 103)	4 Months vs Baseline, p
Checked consciousness	85.4	98.1	0.002	91.3	0.28
Checked pulse	76.7	88.3	0.03	86.4	0.07
Initiated rescue breathing and chest compressions	88.3	97.1	0.03	90.3	0.65
Placed AED electrodes correctly	95.1	82.5	0.07	87.4	0.08
Cleared patient during AED analysis	43.7	70.9	0.0001	60.2	0.02
Cleared area before shock	48.5	73.8	0.0002	67.9	0.005

The mean time to successfully deliver a shock was 74 ± 25 seconds at baseline. Compared to baseline, time to shock significantly decreased at 3 weeks (50 ± 17 seconds, $p < 0.001$) and the faster time was maintained after 4 months (47 ± 18 seconds, $p < 0.001$). The percentage of subjects who successfully delivered a shock also increased across the study. At baseline, 75% of students successfully delivered a shock within 90 seconds; this increased to 98% of students at 3 weeks and 100% at 4 months ($p < 0.001$ for both time points compared to baseline).

Responses to the automated external defibrillator counseling questions were inconsistent in regard to content and reproducibility. No student was able to list 5 or 6 signs and symptoms of sudden cardiac arrest that had been discussed during lecture. The percentage of students able to list at least 3 signs and symptoms at each testing point were 42.7% at baseline, 51.5% at 3 weeks ($p = 0.21$ vs baseline), and 43.7% at 4 months ($p = 0.89$ vs baseline) (Figure 1). The most frequently recalled signs and symptoms were sudden loss of responsiveness, abnormal breathing, and racing heartbeat (Figure 2). When comparing students' 3-week and 4-month responses to those at baseline, there were significant differences in students' ability to recall and list other signs and symptoms; however, recall ability did not correlate with the amount of time that had transpired from baseline. A majority of students were able to recall battery expiration as an important detail for proper automated external defibrillator maintenance (baseline = 86.4% vs. 3 weeks = 88.3%, $p = 0.67$; baseline = 86.4% vs. 4 months = 73.8%, $p = 0.02$). Fewer students were able to remember that keeping the

device clean and inspecting it and the electrode wires for cracks were important (baseline = 41.7% vs. 3 weeks = 48.5%, $p = 0.33$; and baseline = 41.7% vs. 4 months = 33%, $p = 0.19$). The most commonly recalled situations in which additional actions or considerations should be taken prior to placing pads were removing the victim from water, removing excess chest hair, and removing transdermal patches (Table 2).

DISCUSSION

The novel finding of this study was that pharmacy students were able to successfully deliver a shock within 90 seconds after turning on an automated external defibrillator and had maintained this ability when retested at 4 months. The percentage of students who successfully delivered a shock also increased and remained high 4 months later. Our work builds upon past studies demonstrating that laypersons, students, and other healthcare professionals can be trained to use an automated external defibrillator.

In a study by Monsieurs et al, nursing students were handed a fully automatic or semi-automatic LifePak CR Plus external defibrillator trainer (Medtronic Emergency Response Systems, Inc., Redmond, WA), and without training or explanation, instructed to use it on a manikin.¹⁶ Mean times from turning the automated external defibrillator on and placing electrode pads was 62 and 56 seconds, respectively ($p = 0.04$). An additional mean time of 21 and 22 seconds, respectively ($p = 0.014$), was required for delivery of first shock. However, the investigators noted safety errors with clearing the victim during automated external defibrillator analysis and shock delivery.

Figure 1. Percentage of students that correctly identified the corresponding number of signs and/or symptoms of sudden cardiac arrest at baseline (dark bars), 3 weeks later (light gray bars), and after 4 months (dark gray bars).

Figure 2. The percentage of students that correctly identified each particular sign or symptom of sudden cardiac arrest at baseline (dark bars), 3 weeks later (light gray bars), and after 4 months (dark gray bars).

Despite multiple diagrams on electrode pad placement, only 35% of the nursing students correctly positioned the pads on the manikin.

In a study by Beckers et al, medical students were provided an automatic or semi-automatic Physio-Control LifePak CR-T external defibrillator trainer (Medtronic Emergency Response Systems, Inc., Redmond, WA) and instructed to use the device on a manikin without instruction.¹³ Mean time to shock delivery was 81.2 ± 19.2 seconds. After attending a brief lecture 1 week later focusing on the treatment of sudden cardiac arrest, the mean time to shock significantly decreased to 56.8 ± 9.9 seconds ($p < 0.01$). The majority of students correctly placed the electrode pads (92.8%) and safely delivered the shock (97%). The investigators concluded that untrained laypersons (ie, first-year medical students) could successfully and safely use an automated external defibrillator with no instruction, but performance improves after brief instruction and prior use.

In a follow-up study, Beckers et al assessed automated external defibrillator skill retention in medical students after initial training and 6 months later.¹⁴ Compared to baseline, mean time to shock decreased significantly from 77.7 ± 17 seconds to 56.5 ± 9.5 seconds ($p < 0.01$) after initial training and was maintained 6 months later (59.9 ± 8.9 seconds, $p < 0.01$).

Our findings add to previous investigations by illustrating that pharmacy students can quickly and successfully deliver a shock to a victim in sudden cardiac arrest. Like Beckers et al, our study protocol included a lecture and initial training to optimize student performance. However, it differed in that we asked students to initiate CPR on the victim until automated external defibrillator arrival and mean time to shock likely would be reduced if this step were removed. One explanation as to why our students delivered a shock faster than other student groups studied is that our curriculum requires basic life support certification and the mean time from the students

Table 2. Pharmacy Students' Knowledge of Special Situations Requiring Additional Action/Consideration Prior to Using Automated External Defibrillators, %

Special Situation	Baseline (n=103)	3 Weeks (n=103)	3 Weeks vs Baseline, <i>p</i>	4 Months (n=103)	4 Months vs Baseline, <i>p</i>
Remove patient from water/dry patient	76.7	86.4	0.07	77.7	0.87
Remove excess chest hair	74.8	85.4	0.055	73.8	0.87
Remove transdermal medication patches	57.3	79.6	0.0006	58.3	0.89
Place electrode one inch away from implanted devices	43.7	62.1	0.008	57.3	0.051
AED approved for use in children > 1 years of age	22.3	22.3	1.0	26.2	0.52

receiving BLS certification to initial testing was approximately 4 months. The percentage of students that omitted important safety steps and correct pad placement at each testing point was disappointing, especially given their previous training with an automated external defibrillator. Although pharmacy students were able to successfully deliver shocks 4 months after initial testing, we cannot extrapolate these findings to longer time periods. Medical students were able to retain their ability to deliver a shock after 6 months,¹⁴ but to our knowledge, longer periods of time have not been assessed in student populations. As a result, future investigations should evaluate longer time periods to determine optimal intervals for refresher training in the use of automated external defibrillators.

Previous studies also have demonstrated that laypersons can successfully use an automated external defibrillator with little to no training,^{18,19} while others have reported that brief training sessions can improve people's ability to use an automated external defibrillator.^{13,19-22} Notably, 2 of these studies enrolled college students as participants, individuals who are not the most likely person to respond to a sudden cardiac arrest of a spouse or family member in the home.^{13,22} Meischke et al reported that adults over 60 years of age can be trained to deliver a shock but the skills were not maintained at 3 month follow-up testing.²³ One possible solution to improving skill retention and the likelihood of using an automated external defibrillator correctly during sudden cardiac arrest is for pharmacists to provide frequent reminders and retraining to patients and family members who purchase these devices.

Our study differs from previous work by including automated external defibrillator counseling. To our knowledge, no other research has examined the ability of healthcare professionals or students to provide information necessary to educate and support laypersons on the care and use of an automated external defibrillator. A goal of incorporating automated external defibrillator training into the curriculum was to allow students to "see one, do one, teach one," on the premise that increasing students' knowledge and confidence in using an automated external defibrillator would increase their likelihood of later counseling a layperson on this device once they become pharmacists. While our students were able to successfully deliver a shock and retain this skill, they did not retain knowledge of all the competency components for automated external defibrillator counseling. One potential explanation is that students did not apply automated external defibrillator knowledge following the lecture, such as through a simulated counseling scenario. Possibly, automated external defibrillator skills were retained due to hands-on testing rather than to a conventional written ex-

amination used for testing of automated external defibrillator counseling competencies. As such, students may have benefitted from follow-up training on automated external defibrillator function and maintenance. Also, students may have focused their attention on automated external defibrillator demonstration techniques rather than on automated external defibrillator counseling. In the future, automated external defibrillator skills and counseling training of pharmacy students could be optimized with the addition of practical counseling experience and/or further emphasis on counseling importance. Pharmacy students (or pharmacists) should receive intermittent refresher training courses on automated external defibrillator competencies to further develop and maintain their ability to educate laypersons regarding this medical device.

CONCLUSION

This study demonstrated that pharmacy students are able to quickly deliver a shock with an automated external defibrillator and retain this skill 4 months after initial testing. Not only must pharmacy students be able to use an automated external defibrillator, but they also must be able to instruct others on its use and maintenance. A single lecture on automated external defibrillator function and use is not sufficient and short refresher courses should be incorporated into the curriculum in order to enhance knowledge retention. Further research is required to evaluate the education, performance, and retention of automated external defibrillator knowledge and skills with practicing pharmacists.

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