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A Simulation-Based Program to Train Medical Residents to Lead and Perform Advanced Cardiovascular Life Support

Mihaela S. Stefan, MD^{1,2}, Raquel K. Belforti, DO^{1,2}, Gerard Langlois, PA^{2,3}, and Michael B. Rothberg, MD, MPH^{1,2}

¹Division of General Medicine, Baystate Medical Center, Springfield, MA

²Tufts University School of Medicine, Boston, MA

³Baystate Simulation Center, Baystate Medical Center, Springfield, MA

Abstract

Background—Medical residents are often responsible for leading and performing cardiopulmonary resuscitation; however, their levels of expertise and comfort as leaders of advanced cardiovascular life support (ACLS) teams vary widely. While the current American Heart Association ACLS course provides education in recommended resuscitative protocols, training in leadership skills is insufficient. In this article, we describe the design and implementation in our institution of a formative curriculum aimed at improving residents' readiness for being leaders of ACLS teams using human patient simulation. Human patient simulation refers to a variety of technologies using mannequins with realistic features, which allows learners to practice through scenarios without putting patients at risk. We discuss the limitations of the program and the challenges encountered in implementation. We also provide a description of the initiation and organization of the program. Case scenarios and assessment tools are provided.

Description of the Institutional Training Program—Our simulation-based training curriculum consists of 8 simulated patient scenarios during four 1-hour sessions. Postgraduate year–2 and 3 internal medicine residents participate in this program in teams of 4. Assessment tools are utilized only for formative evaluation. Debriefing is used as a teaching strategy for the individual resident leader of the ACLS team to facilitate learning and improve performance. To evaluate the impact of the curriculum, we administered a survey before and after the intervention. The survey consisted of 10 questions answered on a 5-point Likert scale, which addressed residents' confidence in leading ACLS teams, management of the equipment, and management of cardiac rhythms. Respondents' mean presimulation (ie, baseline) and postsimulation (outcome) scores were compared using a 2-sample t test. Residents' overall confidence score improved from 2.8 to 3.9 ($P < 0.001$; mean improvement, 1.1; 95% confidence interval, 0.7–1.6). The average

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Correspondence: Mihaela S. Stefan, MD, Division of General Medicine, Baystate Medical Center, 759 Chestnut St., Springfield, MA 01199. Tel: 413-794-8121, Fax: 413-794-4054, mihaela.stefan@bhs.org.

Conflict of Interest Statement

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score for performing and leading ACLS teams improved from 2.8 to 4 ($P < 0.001$; mean difference, 1.2; 95% confidence interval, 0.7–1.7). There was a uniform increase in the residents' self-confidence in their role as effective leaders of ACLS teams, and residents valued this simulation-based training program.

Keywords

curriculum; cardiopulmonary resuscitation; human patient simulation; residents; advanced cardiovascular life support

Introduction

“At a cardiac arrest, the first procedure is to take your own pulse”—this is 1 of the 13 laws in Samuel Shem's well-known novel *The House of God*,¹ and it is still a suggestion given to residents who are about to become leaders of advanced cardiovascular life support (ACLS) teams. At teaching hospitals nationwide, medical residents are often responsible for directing cardiopulmonary resuscitation (CPR) teams. Residents learn ACLS in a 2-day training course that provides education in current protocols. However, the program only affords residents with limited leadership skills, which are necessary to effectively lead successful ACLS teams. A recent study,² which surveyed one-fourth of all Canadian internal medicine residents, revealed that 49% of residents felt inadequately trained to lead ACLS teams. This finding is not unexpected, as resident leaders often have insufficient training with regard to the leadership skills necessary to direct an emergency situation with a patient in crisis, often in an overcrowded room. While the 2011 American Heart Association (AHA) ACLS manual³ highlights the importance of team leadership, with a chapter specifically dedicated to effective ACLS team dynamic, the actual training provides insufficient opportunity to practice leadership skills. Moreover, skills learned in the ACLS course deteriorate over time,^{4,5} and the quality of ACLS performed in hospitals is inconsistent and often does not meet published guideline recommendations.^{6–8}

To be effective ACLS team leaders, residents need to learn and practice leadership skills in an appropriate setting and as part of a team. Cardiac arrest is a high-pressure, infrequent situation with a life-or-death outcome that often occurs in a room overflowing with people. The leader must be able to “see the big picture” in order to effectively monitor the patient and the team, synthesize all of the information, observe all activities performed by the other team members, and effectively communicate a management plan. The capacity to function as a “commander-in-chief” depends on the ability to understand the leadership role as well as other team members' roles, and is therefore a challenging and demanding task that requires specific training.^{9–11}

Human patient simulation refers to a variety of technologies using mannequins with realistic features, which allows learners to practice through scenarios without placing patients at risk, and provides the opportunity for immediate remediation.^{8,12–17} Clinical simulation enables the learning and training of individuals and teams through the re-creation of specific aspects of a real clinical situation, and is becoming a robust tool for teaching and evaluation.^{16,18,19}

In 2005, Baystate Medical Center (Springfield, MA) opened a patient simulation center. We embraced the basic assumption underlying simulation-based training, in which increased practice in a simulated environment will reduce occurrences of errors in real life, while providing residents with the appropriate attitude and skills. In this article, we describe the initiation and implementation of a simulation-based training program to teach leadership in ACLS, and discuss the limitations of the program and the challenges encountered. We also illustrate residents' improvement in self-confidence and present residents' assessments of the program. A model of repetitive simulation-based training for leadership skills necessary in ACLS, with immediate postdebriefing feedback, is illustrated.

Institutional Program Description

The main objective of the program is to train medical residents as effective leaders of ACLS teams. Based on evidence from the literature,^{8,13–15,20,21} we assumed that using human patient simulation would assist medical residents in improving their performances and acquiring the necessary self-confidence, skills, and behaviors to be effective leaders of ACLS teams.

Setting

The Baystate Medical Center is a 640-bed, university-affiliated hospital in Springfield, MA. All medical residents complete the AHA ACLS course prior to starting their internships. At Baystate, ACLS teams consist of medical residents, an intensive care unit nurse, a respiratory therapist, and an anesthesia resident. The postgraduate year–2 or 3 medical resident who is first to arrive leads the ACLS team. The simulation-based training is conducted in the simulation center, using human patient–simulation mannequins manufactured by Medical Education Technologies, Inc. (Sarasota, FL) and Laerdal Medical Corporation (Wappingers Falls, NY). The simulation center is located in the hospital's main building and has 3 simulation laboratories and 3 classrooms with advanced audiovisual capabilities. The simulator is a computer model–driven, full-sized mannequin with an anatomically correct airway, which can be managed using a bag valve mask or endotracheal tube. The mannequin breathes spontaneously, and has breath sounds, heart sounds, and a pulse; it can be connected to a cardiac monitor, defibrillated, or paced. All cardiovascular, pulmonary, and metabolic parameters can be manipulated by the simulation instructor. The simulator is easy to operate and can be placed in a realistic physical setting. The cases utilized for training are preprogrammed by the simulation instructor, but can be modified as needed during the actual simulated case.

Needs-Assessment Period

From July to September 2006, we observed the residents running simulated ACLS scenarios in the simulation center. During this observational period, we identified the following weaknesses: residents were unfamiliar with operating the defibrillator; resident leaders of ACLS teams attempted to perform tasks rather than delegate and oversee the entire process; leaders failed to verify if the assigned tasks were implemented properly; and leaders often did not explore the differential diagnosis for the underlying cause of the cardiopulmonary arrest.

Based on this assessment and review of the literature,^{4,8,10–15,22–26} we developed a program to teach and improve the leadership skills and increase comfort level of the residents on the ACLS team. We designed case scenarios, surveys, and evaluation forms, and established a team of educators interested in sustaining this program. The simulation instructor, who is consistently present during the simulation sessions, is an AHA ACLS certified instructor. We implemented the ACLS simulation-based leadership training curriculum during the 2006 to 2007 training cycle (Appendix 1A–1C; available online at www.hosppract.com).

Learners

Postgraduate year–2 medical residents and postgraduate year–2 and 3 medical pediatric residents on hospital ward rotation devote 1 hour every week for 4 weeks to the simulation center (group of 4 residents). The number of simulated ACLS scenarios that each resident operates as the team leader depends on his or her performance, which is evaluated by the simulation instructor and the clinician educator. If the instructor concludes that a resident is unprepared, the resident is designated the team leader for additional cases and/or is asked to return for more sessions.

Through collaboration with the Division of Nursing, 1 nurse educator is present for all simulated ACLS scenarios. The nurse educator (2 of whom are ACLS instructors) organizes the venue for floor nurses to participate. Floor nurses volunteer in advance to participate in the ACLS training and are instructed by the nurse educator.

Curriculum Description

The curriculum consists of approximately 8 simulated scenarios with specific objectives. Four 1-hour simulation sessions occur weekly. Each resident is required to participate in the 4-week training 2 or 3 times per year. The ACLS team for the simulated case consists of 4 medical residents, 2 to 3 nurses, and medical students. When the residents are not leading the team, they role-play as other team members, such as the anesthesia resident, respiratory therapist, or other physician. The residents are instructed not to play the same role more than once during each 1-hour session. This approach is logistically easier and has the advantage of cross-training in other functions.

During the first session, the objectives are to introduce competencies in leading ACLS teams, consisting of team member performance monitoring, task delegation, closed-loop communication, systematic approach, reevaluation of the situation, and knowledge sharing. Operation of the equipment used during ACLS, such as the defibrillator and transcutaneous pacemaker, is also reviewed. Orientation to the general rules of the training is a critical component for success. In addition, all medical residents complete a presimulation survey, which consists of questions regarding their self-confidence as ACLS team leaders and knowledge of the ACLS algorithms (Appendix 2A; available online at www.hosppract.com).

During the following three 1-hour sessions, the objectives are to develop competence in leading ACLS teams and practice toward achieving mastery. Each case is designed to last 7 to 8 minutes, with 5 minutes spent on structured, constructive debriefing. The postscenario debriefing session is used as a part of the learning strategy and is facilitated by the

simulation instructor. Team debriefing focuses on the team leader's performance, but also emphasizes organization and teamwork. The debriefing is nonjudgmental, supportive, and constructive. After the fourth session, the survey is administered again (Appendix 2B; available online at www.hosppract.com).

Scenarios

Eight preprogrammed simulator scenarios of different complexities and lengths were developed for the training sessions (based on the *Advanced Cardiovascular Life Support: Provider Manual*³) (Appendix 3A–3E; available online at www.hosppract.com). Each scenario begins with a floor nurse finding a patient critically ill or in cardiopulmonary arrest. The team then responds, assesses, and treats the patient, with 1 resident assigned as the team leader (a photograph of residents performing in an ACLS scenario is available online at www.hosppract.com). The scenario is stopped after 7 to 8 minutes or when the patient is appropriately treated. The scenarios cover the main ACLS cardiac arrest rhythms, including ventricular fibrillation/pulseless ventricular tachycardia, asystole, pulseless electrical activity, supraventricular tachycardia, and bradycardia.

Program Evaluation/Resident Perception

From September 2006 to April 2007, 24 senior residents participated in the ACLS leadership curriculum. To evaluate the impact of this curriculum on residents' self-confidence in leading ACLS teams, we administered a survey before and after the intervention (Appendix 2A, 2B). The analysis of residents' answers to the surveys was approved by the Baystate Medical Center's Institutional Review Board as a part of Baystate Medical Center's Educational Innovation Project. The anonymous survey consisted of 10 questions answered on a 5-point Likert scale, which evaluated residents' self-confidence in 3 main domains: ACLS leadership, equipment management, and cardiac rhythm recognition and management. Respondents' mean presimulation (baseline) and postsimulation (outcome) scores were compared using a 2-sample t test.

Residents' evaluations of the teaching program were very positive. Following the intervention, residents' self-confidence markedly improved on each of the 10 questions (Figure 1); all improvements were highly significant ($P < 0.001$). Residents' overall self-confidence score improved from 2.8 to 3.9 ($P < 0.001$; mean improvement, 1.1; 95% confidence interval [CI], 0.7–1.6). The average score for performing and leading the ACLS teams improved from 2.8 to 4 ($P < 0.001$; mean difference, 1.2; 95% CI, 0.7–1.7). Self-confidence in management of equipment improved from 2.6 to 3.8 ($P < 0.001$; mean difference, 1.6; 95% CI, 0.7–1.8). Recognition and management of cardiac rhythms improved from 2.7 to 3.8 ($P < 0.001$; mean difference, 1.1; 95% CI, 0.8–1.5). More than half of the participants considered the program to be beneficial and two-thirds desired more training before their cardiac intensive care rotations. The training was considered to have promoted critical thinking and understanding of the ACLS team leader role. Based on these evaluations, we concluded that our simulation-based training program for teaching ACLS leadership skills has a positive impact on the self-confidence of residents in leading ACLS teams.

In 2009, we revised our curriculum after reviewing multiple tape recordings of the simulated scenarios, and after group discussions with residents, nurses, and the Critical Care Practice Committee. Despite the increase in perceived levels of self-confidence, our observation of the residents' actual performance revealed that residents struggled with implementing the correct ACLS protocols and recognizing the cardiac rhythms. Our original ACLS leadership curriculum was restructured to include a pre-leadership curriculum that began at the end of the first year of residency. To ensure that each resident has the necessary foundation of knowledge to implement ACLS protocols prior to starting their simulation-based training, a 1-hour lecture and multiple-choice examination focused on rhythm recognition and pharmacotherapy was initiated. The faculty uses examination results to identify struggling residents and to provide feedback and support in understanding the ACLS protocols. Each resident also completes a 1-hour session in the simulation laboratory to review team members' roles and to practice airway management, chest compressions, and defibrillation.

We developed an assessment score sheet for the ACLS team leader, which has a formative role and is used by the simulation instructor for debriefing after each ACLS scenario (Appendix 4; available online at www.hosppract.com). Because of logistic difficulties, this assessment tool and the performance measures included are used only to provide structured feedback for the resident leader in the debriefing session, and the results are not followed over time.

Challenges in Establishing a Simulation-Based Training Program for Developing Leadership in ACLS

The purchase cost for a mannequins used for this program ranges between \$50 000 to \$70 000 depending on the mannequin's capabilities and manufacturer. Currently, Medical Education Technologies, Inc. and Laerdal Medical Corporation are the 2 main commercial vendors of high-fidelity human patient-simulation mannequins in the United States. The salary for a simulation instructor, cost of low-fidelity simulators, and cost of maintaining the simulation facility must also be considered. In our institution, the simulation center is used by multiple departments (eg, residency programs, fellowships, nursing), and the cost is covered by the Department of Academic Affairs.

To maximize the impact of the training made possible by medical simulation, the curriculum must be integrated into the learning environment. This requires restructuring of the residents' and faculty's didactic schedules. Training in ACLS leadership is imperative; however, there are many other scenarios for which the residents are not well prepared, and prioritization of the most important training sessions and how to schedule the teaching is a complex task. In our program, we incorporated the ACLS training as part of the regular teaching sessions to minimize disruption of the residents' schedules. Simulation planning was supported by clear learning objectives with defined goals for each session, active participation, and structured feedback.

Our ACLS simulation training curriculum was started in September 2006 and was improved based on feedback throughout the 3 subsequent academic years. This curriculum is now one of the most recognized and successful programs in the simulation center, and similar

programs have been established for pediatric and surgery residents. Feedback from the residents has shown that this concentrated, repetitive exercise has increased their self-confidence in directing ACLS situations in clinical practice.

The 2010 AHA guidelines for ACLS recognize the need for hands-on practice and retraining in order to build toward mastery, but do not provide specific recommendations for how this should be achieved. The recent guidelines recommend that teamwork and leadership skills training should be included in ACLS courses. The guidelines acknowledge that “manikins with realistic features may be useful for integrating the knowledge, skills and behaviors required in ACLS training” but conclude that “there is insufficient evidence to recommend their routine use in the ACLS courses.”²⁷ Although a number of residency programs have introduced simulation into their curriculum for teaching ACLS, most have developed 1 block of 4 to 8 hours for training without repetition. Perhaps the most rigorous and best-known program is from Northwestern University (Evanston, IL), which was started in 2003 and features 8 hours of deliberate practice.^{8,12–15} Recently, the same group demonstrated that a simulation-based training program significantly improved adherence to AHA ACLS guidelines during actual ACLS events. However, differences between clinical outcomes were not achieved.⁸ General adherence to the guidelines in the trained group was 65%, leading researchers to conclude that repetition is necessary. One of the strengths of our program is the year-long curriculum, with repetition of the 4-hour ACLS training 2 to 3 times during the year. The opportunity to repeat the training is necessary for improved behavior, improved skill retention, and development of expertise.²⁸ A randomized controlled trial of 237 students in Switzerland compared the effect of a short training of leadership instruction in high-fidelity simulated CPR with technical instruction for CPR only. The authors found that leadership training resulted in superior overall CPR and the effect was sustained at 4 months.²⁹

Since publication of the 1999 Institute of Medicine report, *To Err Is Human: Building a Safer Health Care System*,³⁰ there has been a spotlight on medical education and criticism of old teaching paradigms, such as “see one, do one, teach one,” which provide little emphasis on patient safety. The Best Evidence Medical Education systematic review supports the use of simulation technology for medical education,³¹ suggesting that human patient simulation facilitates learning under the right conditions.³²

At our program, simulation is completely integrated into the Internal Medicine Residency curriculum. Based on the feedback from faculty and residents, we have incorporated changes into our curriculum and expanded the simulation-based training. We have developed a “simulation boot camp” for interns to familiarize themselves with the principles of simulation-based education, and we have developed standardized simulated cases for key clinical conditions (eg, arrhythmia, change in mental status, shock). Commitment to simulation-based training at the residency and departmental leadership levels is essential to successful implementation.

Limitations of the Program

First, the ACLS simulation-based training curriculum represents the experience of single residency program. Second, the results that suggest improvement in residents’ self-

confidence comprise a relatively small number of residents. Nevertheless, the improvements were large and uniform. Third, we only measured residents' perceived self-confidence, not their actual performance. Development of the teaching methods using simulation is easier than the use of assessment tools with sufficient validity. In addition, the complexity of the observed behavior renders the assessment difficult and less reliable. As with many other programs, we have decided to focus on the educational component rather than on the assessment. We currently use resident performance evaluated by the assessment tool only for formative evaluation during debriefing.

Conclusion

Implementation of a structured, formal curriculum can increase residents' self-confidence in being effective leaders of ACLS teams. Continued practice provides learners with the opportunity and skills to improve their behaviors as team leaders. Simulation has become an integral part of postgraduate medical education, with the literature supporting its utility. In the era of patient safety and quality improvement, residents should have the opportunity to acquire and apply new knowledge under direct supervision without risk to any patient.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Figure 1.
Residents' responses answered on a 5-point Likert scale with regard to their level of self-confidence in leading advanced cardiovascular life support teams, pre- and post-training.