

Evaluating Simulation-Based ACLS Education on Patient Outcomes: A Randomized, Controlled Pilot Study

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Abstract

Background Simulation training is widely accepted as an effective teaching tool, especially for dealing with high-risk situations.

Objective We assessed whether standardized, simulation-based advanced cardiac life support (ACLS) training improved performance in managing simulated and actual cardiac arrests.

Methods A total of 103 second- and third-year internal medicine residents were randomized to 2 groups. The first group underwent conventional ACLS training. The second group underwent two 2 1/2-hour sessions of standardized simulation ACLS teaching. The groups were assessed by evaluators blinded to their assignment during in-hospital monthly mock codes and actual inpatient code sheets at 3 large academic hospitals. Primary outcomes were time to

initiation of cardiopulmonary resuscitation, time to administration of first epinephrine/vasopressin, time to delivery of first defibrillation, and adherence to American Heart Association guidelines.

Results There were no differences in primary outcomes among the study arms and hospital sites. During 21 mock codes, the most common error was misidentification of the initial rhythm (67% [6 of 9] and 58% [7 of 12] control and simulation arms, respectively, $P = .70$). There were no differences in primary outcome among groups in 147 actual inpatient codes.

Conclusions This blinded, randomized study found no effect on primary outcomes. A notable finding was the percentage of internal medicine residents who misidentified cardiac arrest rhythms.

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Funding: This work was supported in part by National Institutes of Health grants T32 AA013528 and UL1 TR000454 to J.E.H.

Conflict of Interest: The authors declare they have no competing interests.

Content from this manuscript was published in abstract form in *Chest*. 2011;140:1037A and was presented orally at the Chest Conference, Honolulu, HI, October 22, 2011.

DOI: <http://dx.doi.org/10.4300/JGME-D-13-00420.1>

Editor's Note: The online version of this article contains the Megacode skills test, a simulation patient management scenario, and a mock code audit.

Introduction

With increasing emphasis on patient safety and provision of quality care, simulation training is widely accepted as an effective teaching tool, especially in managing high-risk

The authors would like to thank Drs Micah Fisher, Richard Gitomer, Jordan Kempker, Carmen Polito, Anna Von, and Roy Abrahamian and Diana Harmon, Mary Zellinger, Adrienne Pert, Linda O'Sullivan, Sheldon Sloane, Cynthia Alexander, Derrick George, Sandra Jacobs, Jane Bockman, Robin Kirk, Kim Fugate, and Lulu Hong. Most of all, they would like to thank the J. Willis Hurst Emory Internal Medicine Department staff for their support in this study and the Emory Internal Medicine residents who participated in this study.

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Received November 15, 2013; revision received March 24, 2014; accepted April 14, 2014.

situations such as central line placement, airway management, trauma resuscitation, and advanced cardiac life support (ACLS).¹ Various studies of simulation training across specialties show improvement in learner and team performance, communication, and confidence.²⁻⁴

Simulation-based medical education has evolved from increasing learner confidence and clinical knowledge to improving patient care. A meta-analysis of 14 studies comparing effectiveness of conventional clinical education to simulation with deliberate practice found that simulation training improved patient care in obstetric deliveries, laparoscopic surgery, bronchoscopy, and cases of catheter-related bloodstream infection rates.⁵ One study demonstrated improved central line placement after simulation training, with successful insertions in 95% of cases for simulation-trained residents versus 81% for the control group.³ Two studies of simulation training for central line insertion found a reduction in bloodstream infection rates from 3.4 per 1000 catheter-days to 1.0 per 1000 catheter-days⁶ and a reduction of 6.47 per 1000 catheter-days to 2.44 per 1000 catheter-days, respectively, resulting in shorter lengths of stay.^{6,7} Another study found that simulation-based ACLS education improved quality of care during in-hospital cardiac arrest; 68% of simulation-trained residents compared to 44% of conventionally trained residents demonstrated adherence to American Heart Association (AHA) standards, although there were no differences in patient survival.¹

Our aim was to replicate the previously reported ACLS simulation training study to determine whether standardized ACLS simulation training could improve clinical outcomes across multiple hospital sites.

Methods

Setting and Participants

The study period was September 2010 through June 2011. Simulation training was conducted in the Experiential Learning Center laboratory at Emory University School of Medicine. High-fidelity manikins (Resusci Anne simulator, model 150-00001, Laerdal Medical; and HAL 3000 and Noelle S575, Gaumard Scientific) were used to mimic physiological and rhythm changes of real patients.

All second- and third-year internal medicine residents were invited to participate; 103 residents were randomized to 2 groups (FIGURE 1), and only 1 resident declined to participate. Second- and third-year internal medicine residents were selected because trainees at that level are responsible for leading resuscitation efforts during in-hospital cardiac arrests at our institution. All residents participated in an AHA-approved ACLS provider class in 2009 during their internship year.

What was known

Simulation training is widely accepted for facilitating learning in high-risk situations such as advanced cardiac life support (ACLS).

What is new

A study of simulation-based ACLS training for cardiac arrest found no improvement in outcomes relative to standard training.

Limitations

Single institution study and confounding by training year limited generalizability.

Bottom line

Many residents in the intervention and control groups misidentified cardiac arrest rhythms. Future efforts should focus on improving rhythm recognition and rhythm confirmation during actual codes.

Intervention

The control group residents participated in standardized ACLS training during their first year of residency. The simulation group took part in the same training, as well as in two 2 1/2-hour sessions of standardized simulation ACLS training. The 2 groups of residents were evaluated on their performance during in-hospital mock codes and actual inpatient codes at 3 large academic hospitals.

The standard residency ACLS training curriculum consisted of a one-time Megacode test administered during residents' first year of training in the simulation center (provided as online supplemental material). Residents were evaluated using a checklist and received immediate feedback on their performance by 2 physician instructors: a chief medical resident and a hospitalist or critical care physician. Residents who failed the Megacode test were given direct feedback on their deficiencies and were required to retest before completion of their residency.

The standardized simulation sessions provided to the intervention group emphasized code leadership, team management, and adherence to AHA guidelines. Residents were given time to practice with rhythm identification and perform monitor functions. Each resident had the opportunity to serve as code leader, perform cardiopulmonary resuscitation (CPR), defibrillate, and intubate under the supervision of an ACLS instructor or a critical care physician. The first of 2 simulation sessions taught basic ACLS algorithms; the second session involved more complex patient management scenarios, such as diagnosing a pneumothorax after a central line placement as the cause of pulseless electrical activity (provided as online supplemental material). During these sessions, residents were evaluated on their adherence to AHA guidelines by a

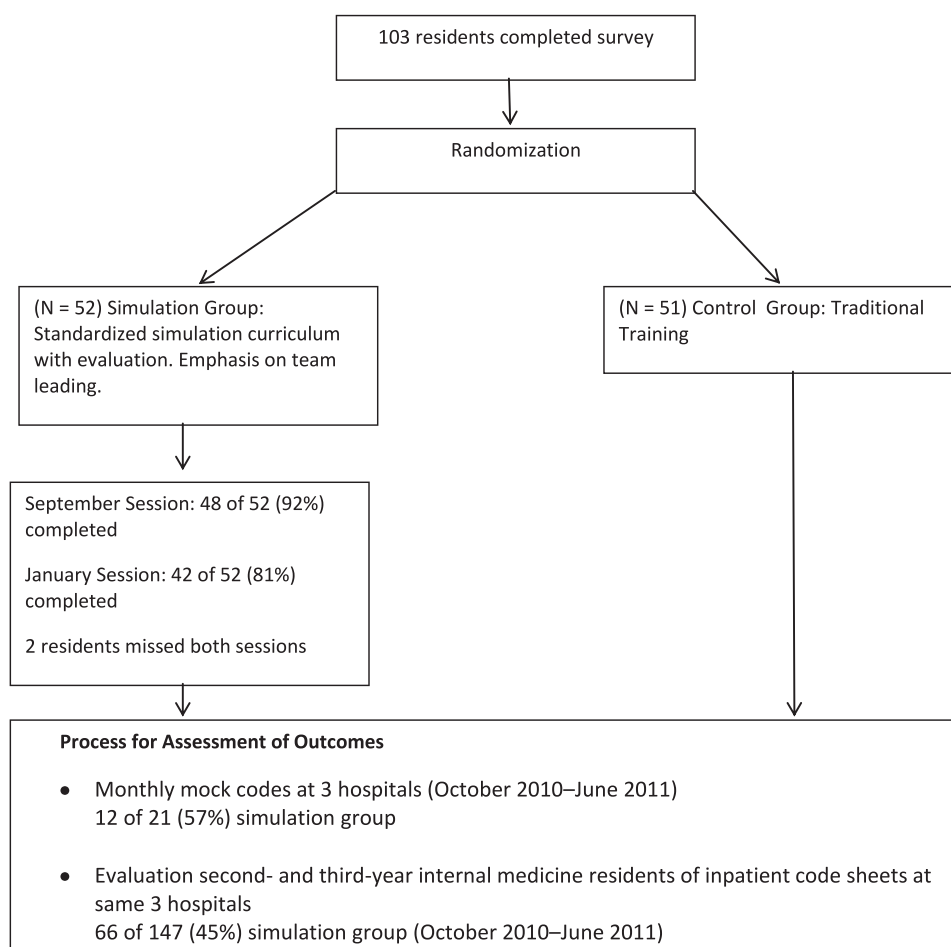


FIGURE 1 | STUDY DESIGN

standardized evaluation form. Their entire performance also was reviewed during a standardized debriefing session immediately after the exercise with video playback and direct feedback. Residents completed anonymous feedback forms eliciting their impressions of the simulation exercises.

The resuscitation committee at each hospital approved the performance of the mock codes, which were conducted in hospital, using a high-fidelity manikin. Participants were unaware of the date, time, and location of each mock code until they arrived at the hospital bedside and were instructed to treat the manikin as a real patient. Therefore, every health care provider who normally responds to in-hospital codes responded. There were 2 evaluators at each mock code who were blinded to the residents' group assignment and who used a standardized form to analyze outcomes (provided as online supplemental material). At the conclusion of the scenario, all health care providers participated in debriefing.

To further evaluate the effectiveness of our intervention, we analyzed data from documented inpatient codes (October 2010–June 2011). Two physician evaluators, blinded to resident names and group assignment, reviewed code records to determine whether AHA guidelines were followed; any disagreement in scoring of the code documentation sheet was adjudicated by a third blinded physician reviewer.

Outcomes

Primary endpoints were time to initiation of CPR, time to administration of first epinephrine/vasopressin, time to delivery of first defibrillation, and adherence to AHA guidelines during the mock and actual inpatient codes. In actual patient codes, return of spontaneous circulation and survival also were measured. Time to defibrillation and time to epinephrine/vasopressin were measured from the documented onset of the rhythm, which required treatment with 1 of these therapies.⁸

The Emory Institutional Review Board exempted this study. We still obtained informed consent from participants.

TABLE 1 SURVEY OF RESIDENTS' PERCEPTIONS ABOUT LEADING CODES			
Survey Question Based on the Likert Scale ^a	% of PGY-2 (n = 41)	% of PGY-3 (n = 34)	P Value ^b
<i>Intake survey</i>			
I feel nervous when I am running an ACLS code.	3.72	3.08	.01
I am confident that I can run an ACLS code.	3.44	3.94	.004
I am satisfied with my training in ACLS codes.	2.73	3.44	.003
<i>Follow-up survey</i>			
I feel nervous when I am running an ACLS code.	3.56	2.64	.001
I am confident that I can run an ACLS code.	3.67	4.23	.004
I am satisfied with my training in ACLS codes.	3.08	3.82	.002

Abbreviations: PGY, postgraduate year; ACLS, advanced cardiovascular life support.
^a Likert scale: 1, strongly disagree; 2, disagree; 3, neither agree or disagree; 4, agree; 5, strongly agree.
^b $\alpha < .05$.

Statistical Analysis

Survey results were compared between second- and third-year residents by using 2-group Student *t* tests. Data were summarized using means and percentages with comparisons across groups and level of resident experience. Chi-square tests and Fisher exact tests were used to analyze resident code performance. Two-tailed *P* values of < .05 were considered statistically significant. All analyses were done with SAS/STAT version 9.3 software (SAS Institute Inc).

Results

Of 51 control participants, 40% (20) were PGY-2, 60% (29) were PGY-3, and 41% (21) were women. The simulation arm participants consisted of 60% (32 of 52) PGY-2, 40% (20) PGY-3, and 60% (31) women. On the prestudy survey, there were no differences between groups in their ACLS experience, although second-year residents reported being more nervous and less confident about running codes and less satisfied with their ACLS training than more senior residents (TABLE 1). The simulation experience was very highly rated on a 5-point Likert scale for both sessions. The quality of the debriefing session was also highly rated (4.4 of 5 points). Of 52 residents in the simulation arm, 13 (25%) missed at least 1 session.

Mock Code Results

Twenty-one mock codes were conducted among the 3 hospitals over the study period. Fifty-seven percent (12 of 21) were led by a resident from the simulation group. There were no differences between the control and simulation arms in time to CPR, time to first epinephrine/vasopressin, adherence to AHA guidelines, and time to defibrillation (TABLE 2). The most common error in both groups was

misidentifying the initial rhythm (67% [6 of 9] and 58% [7 of 12] in the control and simulation arms, respectively; FIGURE 2).

Actual Patient Code Results

Across all hospitals, 147 resident-directed inpatient codes were evaluated, of which 66 (45%) were led by a resident in the simulation group. There were no differences between the study arms and hospital sites in the primary outcomes. Adherence to AHA guidelines occurred in 75% (61 of 81) and 68% (45 of 66) of codes run by residents in the control group and simulation group, respectively (*P* = .34). Patient survival at end-of-code was 65% (53 of 81) in the control arm and 60% (40 of 66) in the simulation arm (*P* = .33).

Discussion

This is the largest blinded, randomized study to date that analyzed the effect of ACLS simulation training on patient outcomes. We observed no significant differences in performance in either mock codes or actual inpatient cardiac arrests.

An unexpected finding was poor cardiac rhythm recognition in both study arms, something previous studies have not reported. During the mock codes, most residents misidentified the initial cardiac rhythm; this would likely cause the resident to administer the incorrect medical therapy, resulting in poor adherence to AHA guidelines; during real codes this could potentially lead to misclassification bias. This finding suggests a need for greater focus on rhythm recognition during cardiac resuscitation training, which could lead to improved cardiac resuscitation survival.

Our study suggests that ACLS simulation training for residents may not have any meaningful impact on outcomes. One previous smaller study was able to

TABLE 2 Mock ACLS Results

Clinical Endpoints	No. of Simulation Arm Responses (%) ^a	No. of Control Arm Responses (%) ^b	P Value
Time to CPR			.75
< 2 min	10 (83.3)	7 (77.8)	
2–6 min	2 (16.7)	2 (22.2)	
Time to epinephrine/vasopressin			.61
< 2 min	1 (8.3)	0	
2–6 min	7 (58.3)	6 (67)	
6 min	4 (33.3)	2 (22)	
	n = 6	n = 6	
Time to defibrillation			.05
< 2 min	3 (50)	0	
2–6 min	3 (50)	3 (50)	
> 6 min	0	3 (50)	

Abbreviations: ACLS, advanced cardiovascular life support; CPR, cardiopulmonary resuscitation.

^a n = 12.

^b n = 9.

document an improvement in performance with simulation training, although it included 10 hours of simulation training, compared to 5 hours in the present study.¹ Perhaps more training with more time for deliberate practice would improve patient clinical outcomes, but the feasibility of implementing simulation training across residencies with different clinical demands, program sizes, and resources presents barriers to the wider implementation of ACLS simulation training.

Our study has a number of limitations. With both groups in the same institution, there is potential for

crosstalk between residents in different groups. If a resident from the simulation arm was performing resuscitation with a resident from the control arm, the leader's performance could have been influenced by the other study participant. Nonphysician members of the resuscitation team could also have influenced performance. However, in attempting to capture patient outcomes, there is no way to control for this without directly altering the way in-hospital cardiac arrest codes are conducted.

One potential source of study error is confounding by training year. There was an uneven distribution of PGY-3 residents among study arms leading inpatient codes. Because our study goal was to evaluate patient care outcomes, there was no way to control for this. Another concern is that a quarter of the residents in the simulation arm missed at least 1 session due to clinical conflicts. An additional limitation is that this was a single institution study. Last, the high survival rate across all 3 hospitals at 60% may have diluted any potentially improved patient care outcome resulting from the simulation training.

Conclusion

We found that ACLS simulation training for cardiac arrest did not have any meaningful effect on clinical outcomes. There was increased resident satisfaction with their ACLS training. A novel finding was that a large percentage of residents misidentified the cardiac arrest rhythms. Future efforts in code training should focus on improving rhythm

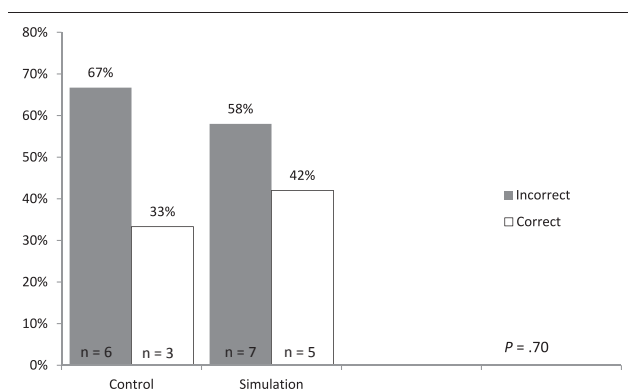


FIGURE 2 Mock ACLS Results

Abbreviation: ACLS, advanced cardiac life support.

Initial rhythm identification in control and simulation arms.

recognition, and institutions should consider methods for rhythm confirmation during actual codes to evaluate correct rhythm identification by practitioners.

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