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Competence in CPR

Nurses need more frequent training to meet new guidelines that emphasize the rate and depth of chest compressions.

Skills need to be used or practiced to maintain competency, and the ability to perform CPR is no exception. Yet nurses in many clinical settings rarely use their CPR skills and may only practice them at the time of course completion—typically every one to two years. This isn't often enough to maintain competency.

Many studies have documented that CPR skills deteriorate rapidly, as early as two months after training.[1-5] This rapid loss in the ability to perform CPR combined with long periods between retraining can be problematic for nurses, who are often the first health care providers to respond to a cardiac arrest and thus need to act quickly and be skilled in their performance.

In a meta-analysis of 53 studies that examined the ability to retain acquired skills, researchers found that motor skills that weren't used or practiced for one year were performed at less than 92% of the original skill level.[6] This is of particular concern regarding skills used in patient care, because, when necessary, they must be recalled immediately and performed with a high degree of accuracy.

Voice advisory manikins and other devices that provide automated feedback on performance can be effective CPR training tools, useful in refreshing skills and potentially helpful in improving the quality of CPR performance.[7-11] Acceptable limits regarding compressions and ventilations are preset in these manikins, which assess CPR performance and deliver corrective audio or visual feedback. If the compressions are too shallow, for example, the manikin will tell the learner to compress deeper, or it will display the compression depth on a screen, providing real-time visual feedback to guide performance.

A nurse practices CPR on a voice advisory manikin. Photo courtesy of Laerdal Medical.

Skorning and colleagues[12] tested a new visual feedback device for its effect on the depth and rate of chest compressions. This small device is placed between the chest of the victim and the palm of the responder and provides feedback regarding compression depth and rate on a color display. Of the 93 health care providers who participated in the study, 45.2% achieved correct compression depth on a manikin without the device; when training with the device in place, this percentage increased to

73.1% ($P < 0.001$). The proportion of providers that performed compressions at the correct rate increased from 62.4% without the device to 94.6% with it ($P < 0.001$).

PRACTICE IS ESSENTIAL

Experts develop their skills by practicing them and receiving feedback on how to improve performance.[13] Few skills can be acquired and maintained with practice only once a year. Some efforts are under way to provide more frequent refreshing of CPR skills. In one hospital, a CPR skill training approach called "Rolling Refreshers" was used in the pediatric ICU to provide "just-in-time" and on-site practice for staff.[14] A cart with a portable manikin and defibrillator that provided practice of CPR skills and automated corrective feedback was brought to the bedside, and staff practiced their CPR skills until they could perform them successfully. The practice focused solely on CPR psychomotor skills, and most of the sessions lasted less than five minutes. Staff who underwent this skill training at least two times per month required less time to achieve proficiency than those who practiced less frequently.

A study we conducted involving more than 600 nursing students confirmed that brief practice of CPR skills is effective in maintaining competence.[15] Students in 10 U.S. nursing programs completed either the American Heart Association's HeartCode basic life support course, which is self-directed and computer-based, or had instructor-led training. Students were then randomly assigned to an experimental or control group. Those in the experimental group practiced their CPR skills on voice advisory manikins once a month, with each practice session lasting six minutes. Those in the control group had no further practice after the initial training.

The students' CPR skills were assessed every three months using a Resusci Anne SkillReporter manikin that measured the quality of compressions and ventilations. With brief and self-directed practice, students in the experimental group maintained their competence in both compression and ventilation skills during the year of the study. At 12 months, most of their CPR skills had improved significantly compared with baseline. The ventilation and compression skills of the students who didn't practice CPR after initial training started to deteriorate by three and nine months, respectively, and few could adequately perform CPR at 12 months.

We've concluded that brief practice of CPR skills on manikins with automated, corrective feedback is effective in maintaining or improving CPR skill competence. While students in the study practiced monthly, it's likely that nurses who've been trained multiple times in basic life support wouldn't need to practice this frequently to retain their skills, although the optimum frequency isn't known. The students in our study used voice advisory manikins for self-directed practice, but other types of devices that provide feedback and prompts, individualized sessions with instructors that focus on performance gaps, and performing CPR as part of simulations may be equally effective in refreshing skills.

Shifting the focus from practicing only at the time of certification to regular assessment and maintenance of competence will only occur if opportunities for practice are available and easy to access—and if health care providers are aware of the need to frequently refresh their skills. Useful strategies might include placing manikins on the unit and in the clinic (allowing staff to practice when they have time) and integrating brief CPR practice sessions into other educational offerings.

Table 1. CPR Skill Levels of Nursing Students (N = 606)[a]

CPR Skill	Mean (SD)
Compression depth in millimeters	35.3 (9.2)
Average compression rate per minute	107.2 (15.8)
Ventilation volume in milliliters	442.8 (249.6)
Average ventilation rate per minute	9.6 (7.4)

[a] Unpublished data from our original study[15]; data collected immediately following successful completion of CPR course.

NEW GUIDELINES FOR CPR

Our research shows that the quality of chest compressions and ventilations provided by nursing students is generally poor—despite the fact that those students we studied successfully passed basic life support courses. Quality CPR—particularly the quality of chest compressions[16]—contributes to the patient's survival from a cardiac arrest.[16, 17]

Chest compressions. How well are nurses trained in CPR, and can they meet the recommendations set forth in the *2010 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care*?[18] These are the first new CPR guidelines in five years, and they include a major change to the sequence of basic life support, directing responders to begin chest compressions before providing ventilation. Chest compressions directly affect blood flow, and beginning resuscitation with compressions helps to ensure as little delay and interruption of blood flow as possible. (For a video from the American Heart Association on how to perform chest compressions, go to http://links.lww.com/AJN/A41.)

It's now recommended that responders start CPR with 30 compressions rather than two ventilations, with a compression–ventilation ratio of 30:2. The guidelines also recommend compressing at least 100 times per minute to a depth of "at least 2 inches

Table 2. Ability of Nursing Students (N = 606) to Meet 2010 American Heart Association Guidelines for CPR[18, a]

CPR Skill, 2010 Guideline	Students Meeting Guidelines		Students Not Meeting Guidelines	
	n (%)	Skill Level, Mean (SD)	n (%)	Skill Level, Mean (SD)
Compression depth, ≥ 51 mm	24 (4)	54.1 (3.2)	581 (96)	34.5 (8.8)
Compression rate, ≥ 100/min	438 (72)	113.5 (12)	167 (28)	90.7 (12.2)
Ventilation volume, 500–600 mL	112 (19)	549 (29.3)	< 500 mL	
			347 (57)	283.4 (187.2)
			> 600 mL	
			144 (24)	744.5 (121.6)
Ventilation rate, 8–10/min	124 (21)	9.1 (0.8)	< 8/min	
			226 (37)	2.7 (2.9)
			> 10/min	
			253 (42)	16.2 (6.2)

[a] Unpublished data from our original study[15]; data collected immediately following successful completion of CPR course. The numbers of students do not sum to 606 because of missing data.

(5 cm)"—51 mm—in adults (the previous guidelines recommended a compression depth of 38 to 51 mm).[18, 19] Because chest compressions are critical to providing blood flow during CPR, providers need to "push hard and push fast," according to the 2010 guidelines.[18]

Yet most nursing students in our study weren't able to achieve the correct depth of compressions. The quality of the chest compressions and ventilations provided by the students was assessed using the Resusci Anne SkillReporter manikin immediately after they had successfully passed a basic life support course. The students' rates of compression were consistent with the new guidelines: of the 606 students we studied, according to unpublished data from our original study, most (n = 438, 72%) compressed at least 100 times per minute, with a mean compression rate of 107.2 (SD = 15.8). The mean compression depth, however, was only 35.3 mm (SD = 9.2), far less than the recommended depth of at least 51 mm, and not even adequate to meet the 2005 recommendations. Only 24 students, just 4% of the entire group, compressed deep enough to meet the new guidelines, and the mean depth of compressions in this group was only 54.1 mm (SD = 3.2) (see Tables 1 and 2[18]).

The inability of students certified in basic life support to compress deep enough is an important finding—and one that supports the results of other studies. Abella and colleagues[20] found that compression rates were less than 90 per minute 28.1% of the time, and compression depth was too shallow (< 38 mm) in 37.4% of compressions, during attempts to resuscitate patients who'd suffered in-hospital cardiac arrest. Mean compression depths were also shallow (34 mm) in a study of the quality of CPR provided by paramedics and nurse anesthetists on patients who had out-of-hospital cardiac arrests.[10] Among non-ICU nurses, 74% of compressions were found to be less than 40 mm in depth.[21]

These findings raise questions about the ability of instructors to gauge whether learners are compressing to an acceptable depth. In a study comparing instructors' assessments of CPR skills with data collected using a Resusci Anne SkillReporter manikin, Lynch and colleagues[22] found that CPR instructors' ratings of ventilation skills were highly accurate, but inadequate compression depth was rated adequate 55% of the time.

Considering the importance of compression depth, learning to compress properly is a critical skill all health care providers must develop. To do so, they need specific feedback to guide how deep they're pushing. It may be that our current training methods don't guide learners in how deep to compress, that they need more practice with corrective feedback at the time of training, or that they need deliberate practice after training to develop this skill.

Duty cycle. As described by the American Heart Association in its 2010 guidelines, "'duty cycle' refers to the time spent compressing the chest as a proportion of the time between the start of 1 cycle of compression and the start of the next."[18] Although duty cycles ranging from 20% to 50% can result in adequate—though not ideal—blood flow, a duty cycle of more than 50% leads to less coronary blood flow. The 2010 guidelines recommend a duty cycle

of 50%,[18] which was achieved by most of the students in our study (n = 484, 80%). Their "hands-off time" (pauses in chest compression) was less than five seconds (n = 565, 93%).

Ventilation. There was variation in the number of breaths students delivered when their CPR skills were assessed. The 2010 guidelines recommend eight to 10 breaths per minute,[18] but less than a quarter (n = 124, 21%) of the students in our study were within that range. Another skill not sufficiently developed after basic life support training was ventilating with an adequate volume. Only 112 students (19%) achieved ventilation volumes between 500 and 600 mL, the recommended volume, and more than half (n = 347, 57%) delivered less than the minimum (see Table 2[18]).

Among the nursing students in our study, there were no differences in any CPR skills based on age, on whether students were previously certified in basic life support, or on whether they had actually performed CPR (several were medics).

RECOMMENDATIONS

Only a few prior studies have evaluated the quality of nurses' CPR skills, but it appears that nurses—like other health care providers—are unable to adequately perform some CPR skills, especially compressing to sufficient depth. Trowbridge and colleagues[23] recommend that those performing chest compressions switch with another rescuer after two minutes, to prevent performance deterioration.

Manikins that provide corrective feedback, and visual feedback devices that allow nurses to recognize the depth and rate of their compressions, may be beneficial during training and when refreshing skills. More ergonomic CPR equipment might also play a role in improving CPR performance.[24] In addition, an increased focus on the depth of compressions in instructor-led CPR courses and frequent practice are imperative considering the new guidelines and research findings highlighting the importance of adequate compression depth. ▼

Keywords: basic life support, chest compressions, CPR, CPR guidelines, ventilation, voice advisory manikin

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REFERENCES

1. De Regge M, et al. Basic life support refresher training of nurses: individual training and group training are equally effective. *Resuscitation* 2008;79(2):283-7.
2. Einspruch EL, et al. Retention of CPR skills learned in a traditional AHA Heartsaver course versus 30-min video self-training: a controlled randomized study. *Resuscitation* 2007;74(3):476-86.
3. Madden C. Undergraduate nursing students' acquisition and retention of CPR knowledge and skills. *Nurse Educ Today* 2006;26(3):218-27.
4. Smith KK, et al. Evaluation of staff's retention of ACLS and BLS skills. *Resuscitation* 2008;78(1):59-65.
5. Woollard M, et al. Optimal refresher training intervals for AED and CPR skills: a randomised controlled trial. *Resuscitation* 2006;71(2):237-47.
6. Arthur W, et al. Factors that influence skill decay and retention: a quantitative review and analysis. *Human Performance* 1998;11(1):57-101.
7. Hostler D, et al. The effect of a voice assist manikin (VAM) system on CPR quality among prehospital providers. *Prehosp Emerg Care* 2005;9(1):53-60.
8. Isbye DL, et al. Voice advisory manikin versus instructor facilitated training in cardiopulmonary resuscitation. *Resuscitation* 2008;79(1):73-81.
9. Spooner BB, et al. An evaluation of objective feedback in basic life support (BLS) training. *Resuscitation* 2007;73(3):417-24.
10. Wik L, et al. Quality of cardiopulmonary resuscitation during out-of-hospital cardiac arrest. *JAMA* 2005;293(3):299-304.
11. Yeung J, et al. The use of CPR feedback/prompt devices during training and CPR performance: a systematic review. *Resuscitation* 2009;80(7):743-51.
12. Skorning M, et al. New visual feedback device improves performance of chest compressions by professionals in simulated cardiac arrest. *Resuscitation* 2010;81(1):53-8.
13. Ericsson KA, et al. The role of deliberate practice in the acquisition of expert performance. *Psychol Rev* 1993;100(3):363-406.
14. Niles D, et al. "Rolling Refreshers": a novel approach to maintain CPR psychomotor skill competence. *Resuscitation* 2009;80(8):909-12.
15. Oermann MH, et al. Effects of monthly practice on nursing students' CPR psychomotor skill performance. *Resuscitation* 2011;82(4):447-53.
16. Edelson DP, et al. Effects of compression depth and pre-shock pauses predict defibrillation failure during cardiac arrest. *Resuscitation* 2006;71(2):137-45.
17. Christenson J, et al. Chest compression fraction determines survival in patients with out-of-hospital ventricular fibrillation. *Circulation* 2009;120(13):1241-7.
18. Berg RA, et al. Part 5: adult basic life support: 2010 American Heart Association guidelines for cardiopulmonary resuscitation and emergency cardiovascular care. *Circulation* 2010;122(18 Suppl 3):S685-S705.
19. American Heart Association. American Heart Association guideline for cardiopulmonary resuscitation and emergency cardiovascular care. Part 4: adult basic life support. *Circulation* 2005;112(24 Suppl):IV-19–IV-34.
20. Abella BS, et al. Quality of cardiopulmonary resuscitation during in-hospital cardiac arrest. *JAMA* 2005;293(3):305-10.
21. Verplancke T, et al. Determinants of the quality of basic life support by hospital nurses. *Resuscitation* 2008;77(1):75-80.
22. Lynch B, et al. Assessment of BLS skills: optimizing use of instructor and manikin measures. *Resuscitation* 2008;76(2):233-43.
23. Trowbridge C, et al. A randomized cross-over study of the quality of cardiopulmonary resuscitation among females performing 30:2 and hands-only cardiopulmonary resuscitation. *BMC Nurs* 2009;8:6.
24. Bauman EB, et al. An evaluation of bag-valve-mask ventilation using an ergonomically designed facemask among novice users: a simulation-based pilot study. *Resuscitation* 2010;81(9):1161-5.