HeartCode™ BLS with Voice Assisted Manikin

for Teaching Nursing Students: Preliminary Results

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Ability to perform cardiopulmonary resuscitation (CPR) is a critical skill for nurses, who are often the first responders to cardiac arrests in hospitals. The chances for patient survival are improved with immediate and high quality CPR (Abella, et al., 2005; American Heart Association [AHA], 2008; Perkins et al., 2008; Wik Myklebust, Auestad, & Steen, 2005). However, any given nurse in day-to-day practice settings may use CPR skills infrequently.

Nursing students are expected to have an understanding of CPR and the ability to perform the basic skills, completing a course prior to entering the nursing program or beginning their clinical practice. At this time, there is limited research on nursing students’ ability to perform CPR. However, studies suggest that skills developed from a CPR course are lost quickly when they are not practiced. In a quasi-experimental study, Madden (2006) examined the retention of CPR skills of 55 nursing students in Ireland. While students acquired CPR knowledge and skills immediately following their instructor-led (IL) course, there was a significant deterioration of skills at the 10-week posttest. An important finding was that even though students learned about CPR and could demonstrate the skills, they could not pass the CPR skill assessment at any time in the study. Kardong-Edgren and Adamson (2009) assessed videotapes of students performing CPR as part of a simulation 22 weeks after passing a CPR course. None of the students could perform the key components of CPR correctly.

The lack of retention of CPR skills among nursing students is consistent with findings of studies with other health care providers and lay rescuers: CPR skill deteriorates more rapidly than does CPR knowledge (De Regge, Calle, De Paepe, & Monsieurs, 2008; Hammond, Saba, Simes, & Cross, 2000; Smith, Gilchrist, & Pierce, 2008; Spooner et al., 2007; Young & King, 2000). Smith et al. (2008) proposed a number of variables that can affect skill retention, including insufficient practice, too much time between the course and actual practice, lack of supervision and feedback during learning, lack of consistency in and quality of the teaching of CPR, and the complexity of the skill being taught.

Instructor-led CPR courses have several potential limitations. The pace of the course is preset, which does not allow adaptation to individual learning needs of students, particularly with regard to providing enough practice time. While instructors are certified, they may not accurately assess performance or correct errors. In a study by Lynch, Einspruch, Nichol, and Aufderheide (2008), 826 lay persons were trained in CPR, followed by an assessment of five CPR skills by 13 AHA-certified instructors. CPR skills also were assessed using sensorized Resusci Anne® manikins with Laerdal PC SkillReporting™ software. Instructors were able to accurately rate participants’ ventilation skills but not their chest compressions or hand placement.

Several innovative methods, such as video self-instruction, have been developed to improve CPR training (Batcheller, Brennan, Braslow, Urrutia, & Kaye, 2000; Done & Parr, 2002; Einspruch, Lynch, Aufderheide, Nichol, & Becker, 2007). In a study by Batcheller et al., 202 lay persons were randomly assigned to either IL training or video self-instruction. Learning was assessed immediately following the training using a Laerdal-Skillmeter™ manikin. Individuals who completed the video self-instruction performed correctly 20.8 percent of compressions and 25.1 percent of ventilations, compared with 3.4 percent of compressions and 1.7 percent of ventilations in the IL group. Overall performance was also better in the video group, leading the researchers to conclude that video self-instruction was an effective and convenient method for CPR training. In another study, retention of CPR skill was no different following

Abstract The purpose of this study was to evaluate the effectiveness of HeartCode™ BLS, a self-directed, computer-based course for obtaining basic life support (BLS) certification. For part 2 of the course, students learned and practiced their cardiopulmonary resuscitation (CPR) psychomotor skills on a voice assisted manikin (VAM). Students from 10 schools of nursing were randomly assigned to two types of CPR training: HeartCode BLS with VAM or the standard, instructor-led (IL) course with manikins that were not voice assisted; 264 students trained using HeartCode BLS and 339 had an IL course. When students passed their respective courses and were certified in BLS, their CPR skills were tested using the Laerdal PC SkillReporting™ System. Students who trained using HeartCode BLS and practiced their CPR skills on VAMs were significantly more accurate in their ventilations, compressions, and single-rescuer CPR than students who had the standard, IL course with regular manikins.
completion of a short video self-instruction program compared to AHA
Heartsaver training (Einspruch et al.).

Recent studies suggest that a voice assisted manikin (VAM) can
improve CPR skill and retention by giving verbal feedback and prompts
during training (Cason, Kardong-Edgren, Cazzell, Behan, & Mancini, 2009;
Chiang et al., 2005; Handley & Handley, 2003; Hostler, Wang, Parrish,
Platt, & Guimond, 2005; Isbye et al., 2008; Sutton et al., 2007; Wik,
In a systematic review, Yeung et al. (2009) found that CPR
feedback/prompt systems, in addition to or instead of an IL course,
improved both CPR skill acquisition and retention. A VAM provides
immediate feedback to learners about their performance and how
to correct it, for example, guiding them to compress faster or to ventilate
more slowly. Yeung et al.'s review indicated that the quality of CPR
improved with VAM training. While research has been done with nurses,
physicians, prehospital providers, and lay persons, studies have not exam-
ined the use of VAMs with nursing students.

Method The current study is part of a larger, multi-arm, multi-site
project examining the effects of brief practice sessions with a VAM on
CPR skill retention for nursing students; practicing nurses, and other
health care providers prepared in electronic and IL courses. The purpose
of this study was to evaluate the effectiveness of HeartCode™ BLS with
VAM for teaching nursing students. HeartCode BLS, a self-directed elec-
tronic course for obtaining basic life support (BLS) certification, has two
parts. Part 1 is the computer-based, cognitive knowledge portion. Part 2
is the CPR psychomotor skills component, which can be completed with
either an AHA-certified instructor or by using the HeartCode BLS/VAM
system. For part 2 in this study, students using the HeartCode BLS sys-
tem learned and practiced their CPR psychomotor skills on a VAM.

Nursing students from 10 schools of nursing throughout the United
States participated in the study. The schools were randomly assigned to
two types of CPR training: HeartCode BLS or a traditional IL course,
which served as the comparison group. Each school had a site coordinator
who was responsible for conducting the research. Coordinators were
educated on the research protocol, trained to set up and use the
manikins, and prepared to implement all other aspects of the study
through a face-to-face meeting at a simulation center; periodic confer-
ence calls, and use of a wiki developed for the study. The random assign-
ments were made by the statistician.

SUBJECTS Students completed the type of CPR training randomly
assigned to their school: 264 students (43.8 percent) were trained using
HeartCode BLS; 339 students (56.2 percent) had an IL course, the stan-
dard four-hour BLS Healthcare Provider course from the AHA.

The sample included 81 students in diploma programs (13.8 per-
cent); 258 in associate degree programs (43.8 percent); and 250 in bac-
calaureate nursing programs (42.4 percent); the other students did not
provide demographic data. There were 82 males, evenly divided between
the HeartCode and IL groups. Nearly all subjects (n = 526, 89.3 percent)
had previously completed a CPR certification course, generally within
the prior year; most (77.9 percent) had current certification. There were
no differences in any of the variables related to previous CPR training
between the two groups. The HeartCode group was slightly older (M =
30.5 years, SD = 9.0) than the IL group (M = 26.1 years, SD = 8.6, p =
0.001).

The study was approved by the Institutional Review Board as a multi-
site study, and written consent was obtained from each student. After
completing their training, students received a two-year BLS certification
from the AHA at no cost.

TYPES OF COURSES Students in the HeartCode BLS group first
completed the computer-based didactic component, including video les-
sons that teach the basics of CPR and guide students through the BLS
algorithms and skills. Students are given realistic case scenarios; they
must assess the patient and decide on the appropriate treatment.
HeartCode BLS uses microsimulation technology, allowing the simulat-
ed patient to respond based on the student’s treatment decisions. Each
case scenario is different, preventing students from memorizing the
actions and ensuring that learning occurs, with the ability to apply con-
cepts. After each scenario, an online report (debriefing) is generated,
explaining incorrect and correct actions. Remediation with links to the
answers is provided for students. At the end of the cognitive portion,
students take a test and must achieve a score of 84 percent to pass. The
cognitive testing is built into the online program, eliminating the need for
paper-and-pencil examinations after course completion.

Once students passed their knowledge test, they practiced CPR on
donors Reausci An™ adult and infant manikins connected to
laptop computers. (See Figure 1.) The VAM software
provides verbal feedback about compressions, ventilations with
bag-valve-mask, and single-rescu-
er CPR. Feedback such as "do
not compress so fast" and "ven-
tilate more slowly" is generated
based on student actions and
the cycle being practiced. When
students complete a cycle, the
manikin asks if they want to continue practicing or use the completed
cycle as their test. An online report showing the number of attempts
and number of adequate compressions and ventilations appears on the
screen. If the completed sequence contains an adequate number of
correct motions, the manikin states that the cycle has been completed
and the student has passed the psychomotor portion of the BLS
course. Students accessed the HeartCode BLS course in their schools’
computer laboratories; however, the course is designed to be done on
any computer at a time convenient for the learner.

In the IL group, students completed the standard AHA BLS
course facilitated by a certified instructor. The study coordinators in
the participating schools of nursing contacted instructors in their
geographic areas and arranged for them to present the course at the
school. In the IL course, students practiced CPR on manikins provided
by the instructor, none of which were voice assisted. Students took
the knowledge test in paper-and-pencil format; their CPR skills were
assessed by the instructor, who observed them perform CPR on the
manikin.

ASSESSMENT OF CPR SKILL When students in both groups
passed their BLS course, their CPR skills were then tested using the
Laerdal PC SkillReporting System. Each student performed three
minutes each of ventilations, compressions, and single-rescuer CPR.
The students' CPR skills were measured by: a) the number of venti-
lations performed correctly (i.e., with volume between 500-800 ml,
inflation flow rate < 800 ml/second, and airway open during the infla-
tion part of the ventilation), and b) the number of compressions
performed correctly (i.e., with depth between 38 mm and 51 mm,
completely released, and with correct hand position). Two-person
CPR skills were not evaluated as part of this experimental assessment.

During the tests of these skills, the Laerdal PC SkillReporter kept
continuous logs of compression and ventilation rates and if the com-
pressions and ventilations were within the adequate ranges. The
SkillReporter also provided a monitor display of each compression
and ventilation. (See Figure 2.) During single-person CPR, it logged
the amount of time in seconds that students had their “hands off”
of the victim's chest when performing ventilations, provided a moni-
tor display of both the compressions and ventilations, indicated
when students used incorrect hand placement during compressions
by noting a “hand” icon on the screen, and displayed the time (in
minutes and seconds) that elapsed since the student began the test.
These monitor displays were visible only to site coordinators, not
to the students. The data on students' performance of CPR skills
were collected by the PC SkillReporting software and sent electron-
ically to the statistician.

DATA ANALYSIS Continuous data were summarized as means,
and categorical data were summarized as frequencies (percents).
Demographic data for the two groups were compared using the chi-
square test and two-sample independent t-test. To compare differ-
ences in CPR performance measures between groups adjusted for
age at time of testing (the only significantly different demographic
covariate between the groups), a mixed linear model, with school
nested within course type, was specified. All significance testing was
done at the 0.05 level (two-sided). SAS 9.1 software was used.

Results Prior to being tested on their CPR skills, all students had
passed their respective BLS courses and received AHA certification.
Students who had HeartCode BLS and practiced on a VAM had signifi-
cantly better CPR performance than students who had the standard
course led by an instructor. Students in the HeartCode group per-
formed more ventilations with no errors (p = 0.02): of their mean 33.1
ventilations (SD = 15.4), 16.4 (SD = 14.4) had the correct volume and
flow rate with the airway opened properly. In comparison, students in
the IL group gave 21.3 ventilations (SD = 23.7), but only 7.9 (SD = 11.9)
of those had no errors. (See Table.)

There were similar findings with the quality of the compressions.
Students who practiced with a VAM were more accurate: of their mean
313.6 compressions (SD = 29.0), 150.8 (SD = 108.5) had no errors.
Students in the IL group, however, had only 82.9 (SD = 107.4) out of a
total of 326.3 compressions (SD = 59.1) with no errors. Compressions
with no errors were those with a depth between 38 mm and 51 mm,
### Table. Differences in Students' CPR Skills between HeartCode BLS and Instructor-led Courses

<table>
<thead>
<tr>
<th>CPR SKILLS</th>
<th>TYPE OF CPR COURSE</th>
<th>INSTRUCTOR-LED</th>
<th>t (df)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of ventilations with no errors</td>
<td>M (SD)</td>
<td>M (SD)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HeartCode</td>
<td>16.4 (14.4)</td>
<td>7.9 (11.9)</td>
<td>2.36 (594)</td>
<td>0.02</td>
</tr>
<tr>
<td>Instructor-led</td>
<td>150.8 (108.5)</td>
<td>82.9 (107.4)</td>
<td>4.69 (593)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Incorrect hand position during compressions</td>
<td>25.6 (69.2)</td>
<td>51.5 (100.5)</td>
<td>2.49 (593)</td>
<td>0.01</td>
</tr>
<tr>
<td>Number of ventilations with no errors during single-rescuer CPR</td>
<td>5.1 (4.8)</td>
<td>3.0 (3.6)</td>
<td>3.97 (596)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Number of compressions with no errors during single-rescuer CPR</td>
<td>121.3 (71.6)</td>
<td>62.8 (70.7)</td>
<td>6.03 (596)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

NOTE. t(df), t-statistic, and p-value from linear contrast specified in mixed linear model adjusting for age

which were completely released, and in which the student had the correct hand position. The differences between groups in the number of compressions correctly performed were significant (p < 0.001). (See Table.) In the IL group, students often used incorrect hand positions during compressions, for example, placing their hands too high or low on the chest or too far to the right or left of the chest. There was a significant difference between the groups in the number of compressions with incorrect hand positions (p = 0.01).

Differences in performance were also apparent during single-rescuer CPR. Students who had used the HeartCode BLS VAM system performed significantly more ventilations (p < 0.001) and compressions (p < 0.001) with no errors in comparison to students who had the IL course and practiced on the manikins without voice assistance.

**Discussion** This study documented the effectiveness of HeartCode BLS with senorsed Reusuci Anne adult and infant manikins for developing nursing students’ CPR skills. Students who completed this interactive, computer-based program and practiced on a VAM were more accurate in their ventilations, compressions, and performance of single-rescuer CPR than students who had the standard IL course required by most nursing programs. With HeartCode BLS, students can pace themselves through the program, reviewing concepts until they achieve mastery at a time convenient for them. The case scenarios allow students to apply concepts, with the simulated patient responding based on the student’s treatment decisions. With debridging built into the program, students receive immediate feedback on the actions they select. These characteristics of HeartCode BLS make this method of learning highly relevant for nursing students with their wide range of learning needs and experiences, preferences for flexibility in instructional methods, and desire to learn in settings of their choice according to their own time frame (Gaberson & Oermann, 2010).

Research has shown that nursing students’ CPR knowledge and skills are not retained (Kardong-Edgren & Adamson, 2009; Leighton & Scholl, 2009; Madden, 2006). As a self-contained, computer-based program, HeartCode BLS could be used for review by students as they progress through the nursing program.

In the HeartCode BLS group, once students passed their knowledge test, they practiced CPR on senorsed Reusuci Anne manikins. The manikins detected when the learner was incorrectly performing the CPR skill, provided immediate verbal feedback, and prompted the student on what to do differently. As students modified their techniques, the manikin continued to give feedback and corrective actions to take, guiding students to improve their performance of CPR skills. The benefits of this continuous feedback and prompting were apparent in the outcomes of this study, with the HeartCode group demonstrating more accuracy in their CPR skills than students in the IL group who did not practice with VAMs.

Although few studies have included nursing students, research with other providers and lay persons suggests that VAMs improve CPR skill and retention by giving verbal feedback and prompts during training, in place of IL courses or in addition to them (Yeung et al., 2009). The findings of this study add to that research evidence. Cason et al. (2009) found that CPR skill performance, following a self-directed learning approach in which students and nurses practiced on a personal, inflatable manikin that provided feedback on performance, was as good or better for some skills than traditional teaching by an instructor.

In this study, even though students passed the IL course and were certified in BLS, they were not able to perform CPR with the same accuracy as those who learned using VAMs. In an IL CPR course, the pace is preset, and students are limited in the time allotted for practice. In addition, instructors may not accurately assess technique nor correct errors in performance. Lynch et al. (2008) found that instructors were able to accurately rate ventilation skills but not chest compressions or hand placement. In contrast, a VAM, by immediately correcting errors in per-
formance with audio feedback, allows students to learn the correct techniques in real time (Sutton et al., 2007).

Through practice experiences with patients and in simulation laboratories, students develop and maintain their psychomotor skills, among other outcomes. This practice is essential for initial learning, to refine competencies, and to maintain them over a period of time (Oermann & Gaberson, 2009). Considering that CPR skills are not retained, the value of nursing students completing one course in BLS is questionable. To maintain skills, students need continued practice of CPR similar to other skills taught in a nursing program. Use of a VAM for acquisition and subsequent practice of CPR skills would allow students to develop correct skills during initial learning and then maintain those skills by practicing periodically as they progress through the nursing program.

Practicing CPR techniques in simulations would not only promote retention but also might improve students’ comfort with BLS and the decisions to be made in code situations. Leighton and Scholl (2009) set up a simulation of an adult patient with an unexpected cardiopulmonary arrest. Students reported that after the simulation, they were more confident in how to respond in a code and had less fear about encountering a patient with cardiac arrest. In that study, most students could not implement BLS actions in the correct order during the simulation, even though they had recently taken an IL course and were certified in BLS.

Site coordinators were asked to evaluate use of the HeartCode BLS VAM system for nursing education. They identified three main benefits of part 1, the cognitive portion: its self-pacing, its interactive and computer-based format, and its ability to indicate the correct and incorrect actions selected by students. For part 2, by practicing CPR on a VAM, students receive immediate feedback on their performance and how to correct their performance as they are learning. Feedback is more specific than in an IL course; the VAM indicates adjustments students should make in their performance (e.g., “compress deeper”), followed by additional feedback and prompting. Coordinators also indicated that with HeartCode, students would be able to practice their skills for longer periods of time if needed, or less time if they were already competent.

Coordinators suggested that the computer-based method of instruction was well suited to the “tech” generation of nursing students. They cautioned, however, that faculty need to complete the instruction themselves to become familiar with the manikin and the feedback given to students, and to be able to troubleshoot any technical issues. In the current study, audio feedback was given via headphones, protecting students’ privacy. Coordinators reported that the headphones appeared to enhance students’ concentration during CPR practice and testing because they limited interruptions and distractions. They recommended use of headphones when practicing on these manikins.

Further study is needed on the HeartCode BLS VAM system for nursing students with English as a second language (ESL). Although the self-paced format would normally be beneficial to ESL students, site coordinators observed that some ESL students had to “translate” the verbal feedback from the manikin as they were learning, affecting its value and the assessment of their CPR skills. Coordinators also reported that students who were overweight appeared to have difficulty using the VAMs. These variables were not examined in the current study but would be important to explore in future research.

Summary Students who completed the self-paced, electronic HeartCode BLS program and practiced CPR on a VAM were significantly more accurate in their ventilations, compressions, and single-rescuer CPR than students who had the standard IL course. These results are consistent with other studies in which performance of psychomotor skills of CPR was improved through use of specific, individualized feedback during training. The findings support the use of the HeartCode BLS training strategy in nursing programs and potentially other medical and paramedical training programs for which a BLS course is appropriate.

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Key Words Basic Life Support – Voice Assisted Manikin – CPR Skills – Cardiopulmonary Resuscitation

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