Impact of a Practice Session using Objective Feedback on
Basic Life Support Skills 12 Weeks Following Initial BLS Training

Thesis

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By

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Abstract

Sudden cardiac arrest is the leading cause of death in the United States. Research

has shown that providing immediate high quality CPR may improve patient's survival.

Although we know high quality CPR may improve outcomes from sudden cardiac arrest,

data still shows CPR patients are receiving is inadequate. Data suggest health care

professional's CPR skills deteriorate quickly upon completion of basic life support

training. Skills decline as soon as 2-3 weeks following initial training. This study aimed

to determine if using objective feedback during initial adult basic life support training in

combination with a practice session using objective feedback would improve student

CPR skills. Students were randomized to either use a traditional CPR manikin during

initial adult CPR training or an objective feedback manikin. Students randomized to use

the objective feedback manikin were asked to participate in a CPR practice session 6

weeks after completing their initial CPR course. During the practice session students

were asked to use objective feedback to correct their skills. While student's practiced

their skills, they were timed to see how long it would take them to perform CPR in

accordance to the 2005 AHA guidelines for CPR and ECC for 2 minutes. To satisfy this

requirement, students must perform CPR within the recommended guidelines for

ventilation rate, chest compression rate and depth, as well as no flow fraction. All

participants were asked to return at 12 weeks for final testing. The ResusciAnne skillreporter manikin was used to collect objective CPR compliance data. Seventeen students participated in the study, 9 treatment and 8 control participants. Due to lack of instructor compliance, determining whether using objective feedback for initial training had an impact on student skills is not answerable. There were no significant differences found in student's CPR skills between those who did and did not participate in the objective feedback CPR practice session.

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Presentations

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Fields of Study

Major Field: Allied Medicine

Minor Field: Research Methods

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Chapter 1: Introduction

Survival rates from sudden cardiac arrest are dismal, killing approximately 350,000 people per year.(1) Half of these events occur in the hospital (1) and reports estimate that approximately 17% of these patients are discharged alive (2-4).

In 2000 there was a renewed emphasis on improving the outcomes when the American Heart Association (AHA) released Guidelines 2000 for Cardiopulmonary Resuscitation (CPR) and Emergency Cardiovascular Care (ECC). These pivotal recommendations encompassed the first international agreement on resuscitation care.(5) The importance of chest compressions during resuscitation from cardiac arrest was not directly addressed by the 2000 AHA recommendations as evidenced by the continued allowance of frequent pauses throughout resuscitation efforts involving stacked defibrillation, frequent rhythm analysis and emphasis on the placement of an advanced airway and IV lines.(6) The importance of chest compressions during resuscitation from cardiac arrest was recognized between 2000 and 2005 when new technology allowing precise measurement of compression and ventilation counts and length of pauses in CPR, during attempted resuscitation of cardiac arrest victims showed long time intervals without any chest compressions.(7;8) The 2005 American Heart Association guidelines stress the importance of chest compressions(9) however poor overall CPR quality is still commonly reported in both the pre-hospital and hospital setting (10-15).

The importance of CPR as it related to outcomes during resuscitation has been documented by several clinical trials (16-18). Poor CPR skill retention translates into poor CPR quality for victims of sudden cardiac arrest (SCA). The most notable flaws in CPR delivery are incorrect compression depth and extended periods without chest compressions being delivered throughout resuscitation attempts. Inadequate chest compression depth compromises circulation, inhibiting the vital flow of oxygen to major organs, including the brain. Interruptions in CPR have been shown to have a negative impact on survival in animal studies.(19) Increasing the rate of chest compressions and minimizing pauses in compressions improve resuscitation rates in animal models of cardiac arrest.(20-23) In humans, out-of-hospital cardiac arrest (OOHCA) resuscitation success was improved when bystanders were instructed by EMS call-takers to administer only chest-compressions for resuscitation versus the standard 15:2 compression and ventilation method.(24) This allowed for the focus on chest compressions and helped eliminate the inadvertent pauses that occur during CPR and worsen outcomes from cardiac arrest. Additionally, three human studies (25-27) illustrated that the quality of CPR can influence sudden cardiac arrest outcomes.

The purpose of this study is to determine the difference in CPR skill 12 weeks post initial BLS training in pre-professional healthcare students based upon teaching method. The research questions to be addressed in this study include:

1. Is there a difference in CPR skill at baseline based upon teaching method?

2. Is there a difference in CPR skill over time for students who participate in the CPR practice session?

3. Are students trained in CPR skills able to achieve compliance with AHA guidelines during a 4 minute practice session using objective feedback?

Definition of terms:

AHA=American Heart Association

CPR=cardiopulmonary resuscitation

ECC=emergency cardiac care

OOHCA=out-of-hospital cardiac arrest

BLS=basic life support

SCA=sudden cardiac arrest

HCP=healthcare professional

NFF=no=flow fraction; fraction of time during resuscitation without chest compressions

occurring

ROSC=return of spontaneous circulation

EMS=emergency medical services

VSI=video self-instruction

TRAD=traditional classroom instruction

BCLS=basic cardiac life support

VAM=visual-audio feedback manikin

Chapter 2: Literature Review

The literature review focuses on CPR quality among healthcare providers and its impact of sudden cardiac arrest (SCA) survival. Additionally, this review sought to determine if retraining and feedback can improve CPR skill retention and CPR quality of healthcare professionals (HCP).

CPR Skill Retention in Health Care Providers

Numerous studies document poor retention of basic life support skills among healthcare professionals. In a study conducted by Gass and Curry, physicians and nurses from a small community hospital attended a traditional program in basic life support cardiopulmonary resuscitation. Researchers found a significant decrease in skill and knowledge at 6 months; and by 12 months both groups were at pre-training levels.(28) Additionally, nursing errors in CPR performance increased from 11 immediately following training to 34 at 6 months.(28) In a follow-up study of 2 medium sized community hospitals, Curry and Gass attempted to determine the rate of CPR skill deterioration. They found that physician and nurse's skills in CPR both deteriorated at 6 months and continued to decline at 12 months. The most common CPR skill error was faulty compression technique.(29) Additionally, they found that regular experience with CPR and perceptions of knowledge and skill were not helpful in determining a need for retraining.(29)

In a study of CPR skill and knowledge retention among newly qualified house officers, Kaye, et al., found that even though CPR knowledge remained unchanged at 5 months, CPR skill significantly declined, including incorrect compression rate and compression depth.(30) In another study of CPR which investigated CPR skill retention, Fossel, et al., retested medical students at 2-3 weeks, 1 year or 2 years following CPR certification without warning.(31) Only three students were able to perform CPR without complications, which included over-ventilation or excessively deep or incorrectly placed compressions, at 2-3 weeks retesting. At 1 year only 2 students could perform CPR without complications and at 2 years only 1 student.(31) In an additional study of CPR retention among pharmacy students 3 months following initial BLS training, only 9% were able to perform the correct sequence of events and only 12% were able to perform safe CPR.(32) Only 6% of students were able to perform both adequate compressions and ventilations, which at the time were 8 breaths per minute and 60 or more compressions per minute.(32)

In 1992 Moser and Coleman published a literature review on recommendations for improving cardiopulmonary resuscitation skills retention. The review summarized 9 studies on skills retention and concluded:

> "most people can successfully learn to perform CPR, skills retention is universally poor. Beginning as early as 2 weeks after initial training, CPR skills begin to deteriorate in a wide variety of subjects including nurses, physicians, emergency medical technicians, family members of patients with cardiac disease, and other lay people".(33)

Additionally, Moser and Coleman review examined methods for improving CPR skills retention. They reviewed 14 articles and found:

> "manikin practice within the 6 months after initial training, at 6 months after initial training, and at 1 year after initial training improved CPR skills retention. Simply retesting for CPR skills with correction of errors improved later skill performance."(33)

In conclusion, CPR skills are poor following initial BLS training, with deterioration beginning as early as two weeks. Furthermore, CPR knowledge is not an accurate indication of students' ability to perform CPR.

CPR Quality of Health Care Professionals

In practice, poor CPR skill retention translates into poor CPR for victims' of SCA. The 2000 AHA guidelines on CPR and ECC, although not explicitly stated, would allow for a no-flow fraction (NFF) of 0.17, allowing a 10 second pause for each minute. A NFF is the fraction of time during resuscitation in which chest compressions are not delivered. In two studies (8;34) of professional EMS first responders adherence to the 2000 American Heart Association (AHA) guidelines for CPR and Emergency Cardiac Care (ECC), chest compressions were not given during the majority of the resuscitation.

In a review of electrocardiograph (ECG) waveforms from November 2001 through November 2002 during OOHCA, Valenzuela, et al., found that 57% of the time chest compressions were not delivered throughout the entire event.(34) The median time without chest compressions was 57 seconds.(34) In a case series study evaluating ECG tracings between March 2002 and October 2003, Wik, et al., found similar results when

examining the quality of CPR of ambulance personnel during OOHCA in Stockholm, Sweden, London, England, and Akershus, Norway. Chest compressions were only administered during 48% of the resuscitation, and 62% of those chest compressions delivered were too shallow.(8) The mean chest compression rate was 121 per minute. Only 28% of chest compressions were in adherence with international guidelines for CPR, meaning they had correct depth 38-51mm with complete release, no leaning or bouncing during chest compression delivery.(8) Also worthy of noting, the 6 patients who survived to hospital discharge had a mean NFF ratio of 0.40 and those who did not survive to hospital discharge had a mean NFF of 0.49; the standard is 0.17.(8)

In an in-hospital prospective review of CPR quality between December 11, 2002 and April 5, 2004, Abella, et al., found that chest compression rates were less than recommended by the AHA, 100 per minute.(7) This review examined the first 5 minutes of each resuscitation separately from the entire event, as the first 5 minutes are the most clinically important and when the best rescuer effort is given based on rescuer fatigue (35). Chest compression rates were less than 90 per minute 28.1% of the time and 12.8% of the time they were less than 80 per minute.(7)   Chest compressions delivered were too shallow (<38mm) 37.4% of the time, ventilations were above 20 breaths per minute 60.9% of the time, while recommended to be 12 to 16 per minute, and a NFF of 0.24, and 40.3% of segments having a NFF greater than 0.20.(7) Although the investigation did not set out to determine if AHA guideline adherence increased rates of return of

spontaneous circulation (ROSC), a secondary analysis was performed and a trend toward lower NFF was observed in patients with ROSC when compared with non-survivors.(7) These articles all conclude that in practice, HCP CPR skill delivery is not in adherence with AHA guidelines. Chest compression rates greatly differ from the guidelines and they are too shallow much of the time. Additionally, the guidelines allow for a 10 second pause per minute for a NFF of 0.17, all of these studies report a NFF much above 0.17, inferring that there are many more pauses occurring than are prohibited to deliver sufficient blood flow during resuscitation.

Impact of Suboptimal Compression and Ventilation Rates on SCA Outcome

More recent evidence related to the importance of maintaining continuous chest compressions is providing the basis for a renewed interest in circulation. Providing a period of chest compressions prior to attempting defibrillation when ventricular fibrillation has been present more than a few minutes may wash out harmful metabolic byproducts, improve acid-base balance, and help generate some adenosine triphosphate in the myocardiocytes.(36) This leads to more successful conversion to a perfusing rhythm during defibrillation.

Cobb, et al., observed that despite the widespread introduction of automated external defibrillators into the emergency medical services (EMS) in Seattle, Washington, OOHCA survival rates remained constant through the 1980's.(37) Seattle EMS system protocols were modified in 1994 to require 90 seconds of chest compressions with

ventilation before analysis of heart rhythm with the automated external defibrillator. The

results of a comparison of the survival rates before and after that change showed an

improvement in survival rates from 24% to 30%.(37)

A subsequent randomized clinical trial of 200 patients with OOHCA in Norway

showed that patients found in ventricular fibrillation had 22% survival to hospital

discharge if they received three minutes of CPR prior to defibrillation compared with

15% when defibrillation was performed immediately.(38) This difference was not

statistically significant, but a pre-specified subgroup analysis suggested that in the group

of patients for which EMS took longer than 5 minutes to arrive, the discharge survival

rate was improved from 4% to 22%, a difference which was highly significantly

significant (odds ratio 7.42, 95% CI 1.61-34.3).(38)

Animal research has demonstrated that the coronary perfusion pressure (CPP)

generated by external chest compression during cardiac arrest is an important factor

predicting restoration of spontaneous circulation and survival.(38;39) CPP is low at the

beginning of each compression cycle and increases only after several chest compressions.

When compressions are stopped for even a few seconds, CPP falls rapidly. To illustrate,

after a CPR cycle of fifteen chest compressions in pigs, CPP was about 21 mm Hg and

fell to 14 mm Hg after a three second pause to give two breaths.(21) Periods without

chest compression as short as 15 seconds, much less than the time required for ECG

rhythm assessment by automated external defibrillators have been shown to worsen mortality.(23;40)

In a study to determine the independent relationship between CPR effectiveness and survival, Gallagher, et al., compared survival rates between those who received effective bystander CPR versus those who did not receive effective bystander CPR. Only 32% of individuals received bystander CPR and of those 46% had it performed effectively. Of those who received effective bystander CPR, 4.6% survived, defined as being awake 14 days post arrest.(41) Of those who received effective chest compressions, but ineffective ventilations (29%), there was a 2% survival. Seven percent received ineffective compressions and effective ventilations for a 0% survival and in the remaining who received both ineffective ventilations and compressions had a 0.6% survival. Among all patients who had ineffective CPR, 1.4% survived. The odds ratio of survival for those who received effective CPR over those who did not was 3.4 (95% CI 1.1 – 12.1).(41)

In 2005, the AHA ECC guidelines placed an emphasis on the importance of high quality CPR.(42) These guidelines called for minimal pauses in compressions both before and after defibrillation; elimination of the rhythm check following defibrillation; alternating chest compression providers every 2 minutes to avoid rescuer fatigue; and delaying intubation to optimize the percentage of time the patient is receiving high quality chest compressions. Since the 2005 recommendations research has shown that

minimal pauses in chest compressions, as provided in cardio-cerebral resuscitation or

minimally interrupted cardiac resuscitation, can increase survival-to-hospital discharge

for OOHCA.(43-45) Each pause in chest compressions can be detrimental to the patient,

casing a rapid decrease in CPP. High quality, effective CPR can lead to better outcomes

from OOHCA.

Training

It is quite clear that traditional CPR training does not translate into high quality

CPR delivery. An important factor in acquiring BLS skills is practice time.(46)

Braslow, et al., found that video self-instruction (VSI) can achieve better CPR skill

performance than traditional classroom instruction (TRAD).(46) In this study researchers

developed a 34-minute training tape focusing on one-rescuer CPR with a "practice as you

watch" approach. CPR skills were compared immediately following completion of either

VSI or TRAD in addition to 60 days following training. VSI students had less

compressions errors including compressions that were too shallow, wrong hand position,

incomplete release, and incorrect compression rate which were all statistically

significant.(46) Additionally, VSI students had less ventilation errors including less

underinflation, overinflation, and gastric distention.(46) Video tape analysis revealed

that students who learned via TRAD were more hesitant and confused when told to begin

CPR. In contrast when told to begin CPR, VSI students immediately began the steps of

CPR.(46) At retention testing there was no significant difference between the VSI and

TRAD groups; however twice as many VSI students were rated competent or better than TRAD students.(46)

Acquisition of psychomotor skill greatly depends on repetition which directly affects skill retention.(47) Overtraining has also been shown to improve skill retention. (48-50) In a 1977 study of CPR skills retention after initial training, researchers concluded that "deliberate overtraining of highly motivated and mature nonmedical basic rescuers results in satisfactory skills retention for at least one year".(50) Police force personnel receiving their initial BLS training were allowed to practice ventilation and compression skills repeatedly. Between 12 and 18 months later, a sub group was randomly selected for retesting. The results showed at retesting that the number of adequate compressions and ventilations remained the same, in addition to the incidence of potentially injurious performance. Potentially injurious performance included excessive ventilation volume, excessive compression force, failure to check for a pulse, or incorrect hand placement.(50)

In an interesting study on retention of a gross motor skills, Melinick took four groups of 20 subjects and had them practice the skill of balancing on a stabilometer; they were grouped by: 0, 50, 100, or 200 percent overlearning.(48) In the 0% overlearning groups, practice was continued until the learning criterion was reached, in the 50% overlearning groups, practice continued until the number of trials was increased by one-half the number required to reach learning criterion, in the 100% overlearning group

practice continued until the number of additional trials was equal to the number of trials needed to reach each criterion, and in the 200% overlearning group, practiced twice the number of trials needed to reach learning criterion.(48) One-half of each group was randomly assigned to a one-week retention interval and the other half was tested for retention at one month. Retention testing was scored by the number of seconds it took each participant to successfully balance on the stabilometer. The results showed that immediate recall of the gross motor skill was facilitated by overlearning. Students who had 200% overlearning had significantly better scores than those who had 0% overlearning following the one-month retention interval.(48) When students from all groups were allotted time to review, there were no significant differences between the groups and relearning occurred rapidly.(48) Thus when students were given time to reacquaint themselves, they quickly retrieve skills.

Yakel found that retesting nurses alone increased CPR competency even without education.(51) In this study 106 nurses from critical care, medical-surgical, and obstetric-psychiatric-clinic were randomly assigned to one of two groups: basic life support-A (BLS-A), a short course that teaches one-person CPR and management of the obstructed airway or basic cardiac life support (BCLS), which covers one-person CPR, two-person CPR, managing the obstructed airway, and infant-child resuscitation. At 4 and 8 months following instruction, nurses were asked to complete a questionnaire on items that may affect their current CPR skill, for example, CPR usage, change in position

or unit, and motivation. Additionally, they were asked to perform CPR for 1 minute.

Students who completed the BCLS course had significantly better skills than those

completing the BLS-A course at both 4 and 8 months independent of area of work, use of

skills or amount of practice.(51) Additionally, nurses from units of high CPR usage such

as critical care had no better skills than those who were from areas of low usage, such as

obstetric-psychiatric-clinic.(51) At retesting students were given verbal correction of

errors. Surprisingly all students performed significantly better (p<0.00) at 8 months than

at 4 months.(51)   Simple retesting was enough practice for students to relearn the skill.

Retraining is important for maintaining psychomotor skills. Retraining has been show to

improve skill acquisition and to aide in skill retention.

Feedback

In a 2001 study by Wik, et al., paramedic students were randomized into two

groups. Group 1 performed CPR without feedback for 3 minutes, followed by a 2 minute

break, and resumed with audio feedback for 3 minutes. Group 2 performed the same

sequence of events but in reverse.(52) Group 1 had significant improvement with audio

feedback. Correct compression depth occurred 32% of the time, while with feedback

92% of the time.(52) In group 2, all three factors mentioned above were performed

correctly, but deteriorated during the following 3 minutes without feedback; however the

percentage of correct compressions was not changed by the removal of feedback. The

authors of this article suggest that visual-audio feedback manikin (VAM) itself and not

practicing alone can improve CPR performance in previously BLS trained paramedic students.(52)

A 2002 study (53) evaluates CPR skill retention in lay responders 6 months following training with VAM. In this study, feedback was prioritized, meaning that feedback was given in order of importance, in order to avoid overwhelming students with feedback when simultaneous errors occurred. Baseline data were collected on the students for 3 minutes without VAM feedback. One week later all students received a 20 minute personal CPR training session with VAM feedback. Immediately following the personal training session, baseline data were collected on each student. One month later students were randomized to either train for an additional 3 minutes twice daily for 5 days using VAM, equating to 50 minutes of training time, or 30 additional minutes of practice. This group was considered over trained. The other group was the control group. Six months later students were asked to perform CPR without VAM and 6 months plus 1 week they were asked to perform CPR with VAM. Testing after the 1 week 20 minute personal training session showed improvements versus testing at baseline.(53) At 6 months, the over trained group had less skill deterioration and performed significantly better than the control group in the number of correct inflations, correct compression depth, and compression rate. In the control group there was no retention of the improved skills over baseline.(53)

In another study evaluating the usage of VAM feedback in BLS training, Spooner et al., explored using VAM during initial BLS training and its effect on CPR skill retention at 6 weeks post training.(54) First year health care students were randomized to either use VAM or standard feedback during initial BLS training. Skill acquisition of was tested immediately following completion of the course and skill retention was tested at 6 weeks post completion. At initial testing, students using VAM achieved better compression depth and more correct compressions. At 6 weeks the VAM group achieved more correct compressions.(54) Although VAM improved initial skill acquisition and retention at 6 weeks, there was still significant decay in CPR skills at 6 weeks, including correct compressions and ventilation in both groups less than fifty percent.(54) These articles all demonstrate that VAM feedback can improve initial CPR skill acquisition and CPR skill retention at 6 weeks and 6 months. VAM leads to better adherence to chest compression rates, depth, and correct inflations.

Chapter 3: Methods

The purpose of this study was to determine the difference in CPR skills 12 weeks post

initial BLS training in pre-professional healthcare students based upon participation in

the CPR practice session. The research questions addressed in this study included:

1. Is there a difference in CPR skill at baseline based upon teaching method?

2. Is there a difference in CPR skill over time for students who participate in the
   CPR practice session?

3. Are students trained in CPR skills able to achieve compliance with AHA
   guidelines during a 4 minute practice session using objective feedback?

This study was a randomized controlled trial. Eligible participants were Allied

Medical pre-professional students enrolled at The Ohio State University, in Allied

Medicine 200 during winter quarter 2009. Participation was voluntary. This study

examined the impact of a targeted CPR practice session on CPR skills 6 weeks following

initial BLS training. Specifically, the CPR practice sessions consisted of a hands-on time

practicing CPR skills on a ResusciAnne Skill Reporter feedback manikin designed to

give real time visual performance feedback.

Allied Medicine 200 was comprised of a 1 hour lecture each week and a 1 hour

laboratory session per week. Students registered to one of 11 laboratory sections of their

choosing. Once students chose their laboratory section, the students within each lab

section were randomized into 2 groups, students who participated in the CPR feedback

practice session and a control group. All students had the same standard assessment at the end of the course and appropriate skill acquisition was determined by the Skillreporter feedback manikin.

The Skillreporter feedback manikin provided continuous feedback on both chest compression rate and depth, as well as feedback on ventilation rate. CPR skill data on each student following completion of the AHA Basic Life Support Course for Health Care Providers was collected and used as baseline data. No students received objective feedback during baseline or final testing. Following completion of the adult section of the course students were asked to perform CPR on the Skillreporter feedback manikin for 2 minutes in order to determine initial CPR skills of each participant and to compare baseline CPR skills, ensuring they are the same at baseline. Throughout the study, CPR compliance was determined by these 2005 AHA guidelines on CPR and ECC:

1. Compression rate:100/min (90-110/min)

2. Ventilation successes: defined by 10-12 breaths per minute (8 breaths total), given over 1 second between 700 and 1000mL.

3. NFF=8.3% (5 second pause per minute)

4. Compression depth=38-51mm

High quality CPR delivery was defined as performing all four variables listed above in compliance with 2005 AHA guidelines on CPR and ECC for 2 minutes.

On observation, all students were able to deliver CPR in the 30:2 ratio suggested by the AHA. Students were instructed to begin with chest compressions. A total of 8 ventilations should have been attempted by every student in the 2 minute time period when starting with chest compressions during both baseline and final testing. Because all students confidently delivered 2 ventilations following every 30 chest compressions, ventilation successes were collected and reported rather than the ventilation rate. Ventilation successes describe the number of ventilations delivered to the Skillreporter manikin that were in compliance with AHA guidelines according to correct volume (700-1000mL) and time (1 second) in which the breath was delivered. Additionally, ventilations that were delivered with a closed airway were not counted. Ventilation successes were ventilations delivered without error.

Six weeks following initial data collection, students randomized to treatment were asked to participate in a CPR practice session. This practice session consisted of the students practicing hands on CPR skills integrated with the continuous Skillreporter feedback manikin. Students were asked to use objective feedback during their practice session and to adjust CPR delivery to be in compliance They were asked to practice CPR on the Skillreporter feedback manikin until they became compliant (for 2 consecutive minutes) with 2005 AHA guidelines on compression rate, ventilation rate, compression

depth, and NFF. If students did not achieve this in 4 minutes, they were permitted to stop. Time taken to reach compliance for 2 minutes was recorded. Students must be compliant with 2005 AHA guidelines 100% of the time for 2 minutes on the 4 variables list above to be determined to have mastered the skill. The Skillreporter feedback manikin provided students with real time feedback on the quality of CPR they were performing so that they could adjust to adhere to 2005 American Heart Association guidelines on CPR and ECC with the objective feedback. Students practiced until they were compliant with compression depth and rate, ventilation successes, and NFF for 2 minutes, or 4 minutes total. During this time the control group, those not randomized to using the Skillreporter feedback manikin during initial BLS training did not attend a CPR practice session.

Twelve weeks following initial CPR training, all students who agreed to participate in the study were asked to return for CPR skills testing using the Skillreporter feedback manikin. Objective feedback was not provided to any students during the final testing. An incentive of a gift card was awarded to those who chose to participate at the final testing.

Objective Measures

Objective data was extracted from the Laerdal ResusciAnne Skill Reporter Manikin. These data points include:

1. Ventilations: average volume, average minute volume, adequate volume, insufficient volume, excessive volume, too short inspiration time, average count per minute, total counted, number without errors, number with airway closed

2. Compressions: average rate, average count per minute, average duty cycle, total count, registered with no errors, average depth, registered with: adequate depth, insufficient depth, excessive depth, hand position too low, hand position too high up, too far to the right, too far to the left, incorrect hand position, incomplete release, average down-stroke/up-stroke ratio

3. Ventilation to compression ratio

4. Hand-off time data: total hand-off time, average hands-off time

High quality CPR was defined by delivering CPR for 2 minutes in compliance with 2005 AHA guidelines on CPR and ECC for chest compression rate and depth, ventilation successes, and NFF.

Data was entered into SPSS v17.0 (Chicago, IL, USA). Descriptive statistics were used to describe CPR skills at baseline and 12 weeks post completion of the AHA BLS for HCP course for both treatment and control groups. An independent samples t-test was used to answer research question number two, comparing final CPR skills between the control and treatment groups. Research question three was answered using descriptive statistics.

Chapter 4: Results of the Data Analysis

Institutional Review Board approval was obtained. A total of 73 students enrolled

in Allied Medicine 200 winter quarter 2009. Of those students, 38 agreed to participate

in the proposed research study. All 38 students participated in the baseline data

collection. Of the 19 students randomized to the CPR practice session 8 students were

absent from lab on the day of the practice session, thus their data are excluded.   Of the

19 students randomized to the control group, 11 did not return for the final data collection

point. The data analysis will focus on the 17 students, 9 treatment and 8 control, who

participated in all randomly assigned data collection points.

On day one of lab, students were checked off on their adult BLS skills; prior to

this they had a one hour course introduction lecture, and thirty minutes to practice adult

BLS skills. Additionally, no students had access to face shields, as the course Professor

did not have them available for students to use on the first day of lab. Although students

were randomized to use the Skillreporter feedback manikin during adult BLS training,

students did not use the device as planned. The manikin was set up and available for use,

however it was not utilized and all but 2 lab instructors used standard CPR manikins for

adult BLS training. Every attempt was made by the study team to ensure protocol

compliance however due to lack of organization on the part of the course Professor, the protocol was compromised and the study outcomes were severely impacted.

AHA CPR and ECC guidelines recommend the following: ventilation successes defined by 8 breaths (a rate of 10 to 12 per minute) delivered over 1 second between 700 and 1000 mL, chest compression depth of 38-51mm, chest compression rate between 90 and 110 and NFF of eight percent. Table 4.1 describes baseline CPR statistics on the 4 measured CPR skill variables of both the control and treatment group. Data were collected on the ResusciAnne Skillreporter manikin without feedback for 2 minutes immediately following initial BLS for HCP training. The control group CPR skill statistics were as follows: average number of ventilation successes 3.25±2.8 breaths, average compression depth 43±10.5mm, average chest compression rate 108.5±18.6 compressions per minute, and 30%±5% of the time the student provided no circulation support. The intervention group baseline CPR skill statistics were as follows: average number of ventilation successes 5.11±2.1 breaths, average compression depth 45±10.6mm, average chest compression rate 124.44±27.2 compressions per minute, and the students provided no circulatory support 38%±12% of the time. Both groups were able to achieve correct chest compression depth at baseline, however they also had extremely inadequate ventilation successes, falling below suggested AHA guidelines. Even though all students attempted to ventilate at the correct rate, students still did not deliver ventilations within the recommended time and volume and additionally did not

open the manikin's airway adequately. Students provided circulatory support three times less than the recommended time. Additionally the control group provided chest compressions at a slightly higher average rate than suggested by the AHA guidelines.

To show both groups had equal baseline CPR skills, an independent samples t-test was employed. The statistical hypothesis of no difference between the means of the 4 measured CPR skill variables was retained at alpha=0.05. It can be concluded that the for the population of students who participated in this study, the mean on the variables "ventilation successes", "compression depth", "compression rate", and "NFF" do not differ significantly between the two groups at baseline, thus we can assume the treatment and control groups had equal CPR skills at baseline. Variances were assumed to be equal by Levene's test for Equality of Variances at alpha=0.05. The group means were very similar at baseline. These data are presented in table 4.1.

	Control n=8	Treatment n=9	t-test for Equality of Means		
	Mean (SD)	Mean (SD)	t	df	Sig. (2-tailed)
Ventilation successes (8 breaths)	1.00 (1.69)	1.89 (2.2)	-0.923	15	0.370
Chest Compression Depth (38-51mm)	42.8 (10.5)	45 (10.6)	-0.439	15	0.667
Chest Compression Rate (90-110 cpm)	108.5 (18.6)	124.4 (27.2)	-1.392	15	0.184
No Flow Fraction (8.3%)	30% (5%)	38% (12%)	-1.724	15	0.105

Table 4.1 Comparison of CPR skills at baseline

Research Question One. Is there a difference in CPR skill at baseline based upon teaching method?

The unfortunate lack of course instructor compliance made it impossible to answer this question. As mentioned in the methods section, the Skillreporter manikin was assembled, ready for use during adult CPR skills practice, however it was only utilized by two instructors.

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Research Question Two. Is there a difference in CPR skill over time for students who participate in the CPR practice session?

Data presented in table 4.2 are an independent samples t-test between the treatment and control groups on the 4 selected CPR skill variables at the final data collection point. The statistical hypothesis of no difference between the means of the 4 CPR skill variables selected was retained at alpha=0.05. Variances were assumed to be equal by Levene's test for Equality of Variances at alpha=0.05. Group means were similar as found at baseline. The CPR practice session with objective feedback 6 weeks following completion of the AHA's BLS for HCP course had no effect on CPR skills 12 weeks following completion of the course. The practice session did not improve CPR compliance with the guidelines; furthermore at baseline, students' CPR skills were not in compliance with the AHA's guidelines for CPR and ECC.

	Control n=8	Treatment n=9	t-test for Equality of Means		
	Mean (SD)	Mean (SD)	t	df	Sig. (2-tailed)
Ventilation successes (8 breaths)	1.25 (2.32)	3.00 (2.78)	-1.398	15	0.182
Chest Compression Depth (38-51mm)	39.5 (8.6)	41.3 (8.4)	-0.445	15	0.662
Chest Compression Rate (90-110 cpm)	110.9 (17.0)	116.4 (34.3)	-0.415	15	0.684
No Flow Fraction (8.3%)	30% (6%)	34% (7%)	-1.186	15	0.254

Table 4.2 Final CPR Skills for Study Participants

Research Question Three. Are students trained in CPR skills able to achieve compliance with AHA guidelines during a 4 minute practice session using objective feedback?

CPR skill practice data from the treatment group is presented in table 4.5. CPR skill statistics were as follows: average number of ventilation successes 3.6±1.1 breaths, average compression depth 43.4±1.5mm, average chest compression rate 105.3±25 compressions per minute, and the students provided no circulatory support 13.8%±6% of

the time. Students should have delivered 16 total breaths during the 4 minute period.

The mean practice time was 217.9±41.6 seconds. Only two students were able to achieve

adequate CPR skills in under the given 4 minutes. Both of these students were able to

achieve CPR compliance in just over 2 minutes which pulled the overall mean practive

time below 4 minutes.

Treatment n=8	Mean (SD)	Min	Max
Ventilation successes (16 breaths)	3.63 (1.1)	2	5
Average compression depth (38-51mm)	43.37 (1.5)	41	46
Average compression rate (90-110 cpm)	105.25 (25.0)	74	157
No Flow Fraction (8.3%)	13.8% (6%)	7.5%	24.6%
Practice Time (seconds)	217.88 (41.6)	138	240

Table 4.5 CPR Practice Session Statistics

Chapter 5: Discussions, Conclusions, and Implications

Baseline CPR skill data were collected from participants upon completion of the adult section of the AHA BLS for HCP course. CPR skill competency was judged by their course instructor for course passing purposes. Even though students were deemed competent in their CPR skills by their lab instructors, both treatment and control groups at baseline had CPR skills that were not in compliance with AHA guidelines. The lack of acquisition of skills at baseline made it impossible to retain skills.

The purpose of the study was to determine if using objective feedback while teaching adult BLS would improve student's skills at baseline. Due to lack of course instructor compliance, as mentioned in chapter 3, only 2 instructors used the objective feedback manikin appropriately during initial training. The manikin was assembled ready for use on the first day of lab; however lab instructor were not given access to the manikin by the course instructor. Another intended investigation of the study was to determine if a practice session using objective feedback 6 weeks post completion of adult BLS would improve CPR skills at 12 weeks. This conclusion cannot be made based on the outcome of this study. Participation in the practice session did not improve student skills.

Overall, student's skills declined rapidly, which is consistent with other literature. Wik et al., performed a study to determine if objective feedback during BLS training

improved paramedic skills at final testing. Results showed student's skills were not in compliance with AHA guidelines and suggested the use of objective measures for determining student's competency instead of the current subjective measures.(53) Fossel et al., found medical student's CPR skills declined as soon as 2-3 weeks following completion of CPR training.(31) Martin et al., retested pharmacy students 3 months after completing CPR training, and found only 6% of students were able to deliver adequate ventilation and compression rates.(32) Health care professional data by Venezuela et al.,(34) and Wik et al.,(8) showed no flow fractions of 57% and forty-eight percent. While these are quite higher than found in this manikin study. The suggested studies examined real world cases, in this study, student's were in a controlled environment and did not have to worry about intubating, starting lines, switching providers, or pushing drugs. They were told to strictly focus on compressions and ventilations. Data analyses determined no students in either the control or treatment group, at baseline or at final testing, were able to adequately perform CPR.

Adequate CPR is defined as being in suggested AHA guideline ranges for ventilation and chest compression rates, chest compression depth, and no flow fractions. It can be concluded that student's CPR skills decline rapidly following completion of the AHA BLS for HCP course. Additionally, while student's skills may be seen as adequate by a course instructor, without the use of objective measures, we may not be accurately testing student's skills. There was an overall trend in the treatment group towards

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improved ventilation rates at final testing; however rates were still not within range of suggested guidelines.

During the practice session, 6 weeks post completion of adult CPR, student's skills were much more in compliance with the use of objective feedback. Mean compression rates and depths were in compliance and while the NFF was slightly higher than recommended, which was quite impressive. Ventilation rates were still not in compliance. Similarly, these findings were found with paramedics, who went from 32% chest compressions with correct depth to 92% with audio feedback.(52) Greater instructor compliance may have allowed us to determine if using objective feedback during initial training may have improved student's skills. It should be noted however student's skills improved with the use of objective feedback from poor compliance at baseline. One suggestion for CPR skill improvement would be for objective feedback to be considered by the AHA as an adjunct to training.

The limitations of the study severely impacted the outcome of the study. First of all, the lack of coordination of the Instructor Training course with the actual instruction of the CPR course laboratories severely impacted the implementation of this study. Although the course Professor in charge of AM 200 was a certified AHA CPR Instructor Trainer, the lab instructors for the course had not completed the portion of their instructor training which required them to be observed while teaching. This might have contributed to the suboptimal skills illustrated by some of the students of said instructors.   There

were also challenges associated with the order in which the skills were taught which impacted skill acquisition at the time of baseline data collection. For example, students were instructed in 1 and 2-Rescuer CPR without practicing mouth-to-mouth ventilations. This was due to the unavailability of face shields and oversight on the part of the course Professor. Due to the limitation of time available within the course schedule, baseline data collection was unable to be rescheduled after the face shields were provided and students were instructed to use them for ventilations.

The lack of adequate training might have lead to poor skill acquisition seen in the baseline data. Instructor variability impacted the outcome of the study, specifically on student CPR skills. Students of certain instructors had very poor CPR skills while other had quite impressive skills. Therefore student's abilities were affected by the assigned instructor's training abilities. Research question one explored the impact of objective feedback during initial adult BLS training, however only 2 instructors followed instructions and used the device for initial training. Thus research question one could not be answered.

In addition, there was a high mortality rate among participants. The dropout rate among overall participants and within each group was approximately fifty percent. Due to the high dropout rate, the final sample size was only seventeen. This limits the generalizability of the results to only those who participated in the study. Furthermore,

study participants were not asked if they had encountered a situation where they had to use CPR in between data collection points. This was threat to history was not controlled. Lastly students may have adapted to the use of the manikin. Final testing data could be affected due to student's previous use of the manikin.

The outcomes of this study show a clear need for improvement in CPR training and education. Data from this study conclude student's skills at baseline are not in compliance with the AHA guidelines, so it is expected they would not be capable of performing adequate CPR in the field. Suggestions for improving CPR training include the use of objective feedback during initial BLS training, more practice time or more frequent hands-on practice requirements, and possibly more frequent renewal of CPR cards. Additionally more time practicing the delivery of ventilations may improve student skills. Ventilating a patient is a more difficult skill to acquire than providing chest compressions. As mentioned in the literature review, ventilations given to patients are positive pressure breaths and these can impede blood flow to the heart. If blood is not moving to the heart and other vital organs then a HCP can give all the ventilations they want, however they are not pushing around the oxygen in the blood. Ventilations have even been removed for lay responders unfamiliar with providing CPR due to their complexity. Providing successful ventilations is a highly skilled task and should require additional teaching time.

Implementing a 4 minute CPR practice session 6 weeks after learning adult CPR using objective feedback, did not impact student CPR skills 12 weeks following completion of the AHA BLS for HCP course. Overall, participants were unable to successfully perform CPR using objective feedback 6 weeks post completion of the AHA BLS for HCP course, however chest compression rates and depth were in compliance with guidelines and NFFs were low. This suggests objective feedback may improve CPR skills.

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Appendix A: Student Recruitment Email

January 14, 2009

Dear AM 200 Students:

I am currently a graduate student in the School of Allied Medical Professions, as well as one of the lab instructors for this course. As part of my requirements for my Master's degree I am completing a thesis and I am asking for your participation. The purpose of the study is look at CPR skill retention over time.

Participation will require minimal extra work on your part. Baseline data collection will occur during your scheduled lab session #3 (January 23rd & 26th), additionally you will be asked to attend your scheduled lab session #9 (March 6th & 9th) to practice CPR for two minutes on a recording manikin. Then, I will contact you by e-mail during early spring quarter to come back a final time for two minutes of CPR during the end of April. Students who participate at all data collection points (lab session #9 and April session) will receive a financial incentive.

I know you have busy schedules but I would greatly appreciate it if you would participate. Your participation is voluntary, and should you choose not to participate, you will not be penalized in any way.

If you have any questions, please feel free to contact me. Should you choose to participate, please review the attached consent form. Your lab instructor will have a copy for you to sign in the next lab.

Thank you for your time,

Sarah Cantrell   Georgianna Sergakis
Cantrell.45@osu.edu   Georgianna.Sergakis@osumc.edu
614-366-8544   614-292-8445

Appendix B: Data Collection Sheet

Testing: Data Collection Sheet

ID:_____

Group (circle one)   A   B

Testing period (circle one)   Baseline   Final

Ventilation Data
- Average Volume: _____

- Average Minute Volume: _____

- Average Count per Minute: _____

- Number without Errors: _____

- Number with Closed Airway: _____

Compression Data
- Average Rate: _____

- Average Duty Cycle: _____

- Total Count: _____

- Registered without Errors: _____

- Average Depth: _____

- Registered with adequate depth: _____

- Incorrect Hand Position: _____

- Incomplete Release: _____

Ventilation:Compression Ratio   _____

Total Hands off Time: _____

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Practice Session: Data Collection Sheet

ID:_____

Time taken to become compliant: _____
(ventilation rate, compression rate and depth, NFF for 2 minutes)

Ventilation Data
- Average Volume: _____

- Average Minute Volume: _____

- Average Count per Minute: _____

- Number without Errors: _____

- Number with Closed Airway: _____

Compression Data
- Average Rate: _____

- Average Duty Cycle: _____

- Total Count: _____

- Registered without Errors: _____

- Average Depth: _____

- Registered with adequate depth: _____

- Incorrect Hand Position: _____

- Incomplete Release: _____

Ventilation:Compression Ratio   _____

Total Hands off Time: _____