AED training and its impact on skill acquisition, retention and performance – A systematic review of alternative training methods

Joyce Yeung [1,2], Deems Okamoto[3], Jasmeet Soar[4], Gavin D Perkins[1,2]

[1]University of Warwick, Warwick Medical School, UK, CV4 7AL

[2]Academic Department of Critical Care, Anaesthesia and Pain, Heart of England NHS Foundation Trust, Birmingham, UK, B9 5SS

[3]Swedish/Ballard Medical Center, Seattle WA, USA

[4]Department of Anaesthesia and Intensive Care. Southmead Hospital, North Bristol NHS Trust, UK, BS10 5NB

Corresponding author:

Dr J Yeung

joyce.yeung@nhs.net

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ABSTRACT

Introduction

The most popular method of training in basic life support and AED use remains instructor-led training courses. This systematic review examines the evidence for different training methods of basic life support providers (laypersons and healthcare providers) using standard instructor-led courses as comparators, to assess whether alternative method of training can lead to effective skill acquisition, skill retention and actual performance whilst using the AED.

Method

OVID Medline (including Medline 1950-November 2010; EMBASE 1988-November 2010) was searched using “training” OR “teaching” OR “education” as text words. Search was then combined by using AND “AED” OR “automatic external defibrillator” as MESH words. Additionally, the American Heart Association Endnote library was searched with the terms “AED” and “automatic external defibrillator”. Resuscitation journal was hand searched for relevant articles.

Results

285 articles were identified. After duplicates were removed, 172 references were reviewed for relevance. From this 22 papers were scrutinized and 18 were included. All were manikin studies. Four LOE 1 studies, seven LOE 2 studies and three LOE 4 studies were supportive of alternative AED training methods. One LOE 2 study was neutral. Three LOE 1 studies provided opposing evidence.

Conclusion

There is good evidence to support alternative methods of AED training including lay instructors, self directed learning and brief training. There is also evidence to support that no training is needed but even brief training can improve speed of shock delivery and electrode pad placement. Features of AED can have an impact on its use and further research should be directed to making devices user-friendly and robust to untrained layperson.

1. Background

Sudden cardiac arrest is a major cause of early death in adults in developed countries. Chest compressions in cardiac arrest victims help preserve the myocardium[1] and prolong the time window for successful defibrillation. Early defibrillation is the strongest predictor of survival from cardiac arrests due to ventricular fibrillation (VF) and pulseless ventricular tachycardia (VT). [2, 3] Time is crucial and each minute of delay in defibrillation of VF/VT can lead to a 10% reduction in survival.[2] Bystander CPR and use of automated external defibrillators (AEDs) before the arrival of emergency medical services (EMS) can have a major impact on outcomes.[4, 5]

AEDs were introduced in 1979 and have been widely used by trained healthcare staff in both in hospital and out of hospital settings. They have been hailed as 'the single greatest advance in treatment of VF cardiac arrests since the development of CPR.'[6] AEDs perform accurate rhythm analysis in adults[7] and children[8, 9] and provide audiovisual prompts, thereby negating the need for rhythm recognition and knowledge of defibrillation protocol, potentially allowing an untrained bystander to defibrillate correctly. AEDs are now considered an integral component of basic life support.[4, 10]

The most popular method of training in basic life support and AED use remains instructor-led training courses.[11] The current format of Basic Life Support and AED course outlined by European Resuscitation Council (ERC) Guidelines 2005 lasts 'approximately half a day' and consists of 'skill demonstrations, hands-on practice and lectures' by a certified BLS/AED trainer. The background of the instructors is not specified but are often healthcare professionals who teach CPR regularly. The recommended ratio of instructors to candidates is 1:6, with at least one manikin and one AED for each group of six candidates. The format of life support courses with AED use recommended by American Heart Association (AHA), Heartsaver AED course, is classroom-based with instructor and video, group interaction and lasts 2.5 hrs.

With the development of AEDs, early defibrillation by the public and laypeople has been made possible. The AHA has promoted the public access defibrillation (PAD)

project, aiming to strategically place AEDS in public places and encourage their uses by both trained first responders and trained bystander. In Italy, Capucci et al invented a system called Piacenza Progetto Vita (PPV), whereby 1285 lay volunteers who were trained in the use of AEDs but not cardiopulmonary resuscitation responded to suspected cardiac arrests in the region of Piacenza. Their results were encouraging with significantly higher neurologically intact survival rates (8.4% in PPV versus 2.4% in EMS treated patients, p=0.009) and survival rate to hospital discharge (10.5% in PPV versus 3.3% in EMS group).[3] In the United Kingdom, early results reported by the PAD program supported the placement of static AEDs in public areas, with significantly better results in achieving return of spontaneous circulation (ROSC) and hospital discharge compared with first responders arriving with AEDs (ROSC 39% static AEDs versus 10% first responders, discharge 26% static versus 2.9% first responders, p<0.001 for both).[12] An analysis of the traditionally taught, instructor led AHA PAD Trial proposed that modification of the teaching method used for the lay providers might have improved their participation and performance in sudden arrest events had the training been made more congruent with their social, employment, ethnic and personal backgrounds. The comment was made that training that is more content and skills driven rather than being formally didactic and technical would transfer the educational content into actual practice better had the training been more individualized and congruent.[13] A recent population cohort study examining the effectiveness of contemporary AED use evaluated more than 13 000 out of hospital cardiac arrests between December 2005 and May 2007. The study concluded that AED application was associated with increased survival (OR 1.75, 95%CI 1.23-2.59, p<0.002) after adjusting for patient characteristics, initial rhythm, provision of bystander CPR, location of arrest and EMS response time. By extrapolating data to population of North America, the authors hypothesised that AED application by bystanders could save 474 lives per year.[14]

This systematic review examines the evidence for different AED training methods using standard ERC and AHA courses as comparators, to assess whether any particular alternative method of training will enhance skill acquisition, skill retention and actual performance whilst using the AED. It expands upon and updates the

evidence synthesis worksheet developed during the Consensus on Science and Treatment Recommendations 2010.[15]

2. Methodology

2.1 PICO question

This review sought to identify evidence to answer PICO (Population, Intervention, Comparator, Outcome) question: in laypersons and healthcare providers (P), does the use of alternative AED training method (I) as opposed to traditional instructor led training (C), lead to effective AED skill acquisition, retention, and performance (O)?

2.2 Search strategy

OVID Medline (including Medline 1950-October 2010; EMBASE 1988- October 2010) was searched using “training” OR “teaching” OR “education” as text words. Search was then combined by using AND “AED” OR “automatic external defibrillator” as MESH words. This search identified 285 articles. After duplicate articles were removed, 172 references were reviewed for relevance. From this 22 papers were reviewed and 18 were included. Additionally, the American Heart Association Endnote library was searched with the terms “AED” and “automatic external defibrillator”. Resuscitation journal was hand searched for relevant articles. All relevant references had been identified with earlier search strategies.

2.3 Study selection

All included studies have examined the effect of alternative training intervention on AED skill acquisition, performance and retention. The broad themes have been divided into training by layperson; shorter instructor based training; self-training (web-based and videos) and minimal training/no training. Studies identified in this review were all manikin based and only one was designed as non-inferiority trials.

2.4 Study classification

Studies were reviewed in detail and classified by level of evidence (LOE) and quality (rated poor, fair or good) according to agreed definitions.[16] Higher quality evidence

studies undertaken on manikins (e.g. randomised controlled trials) were classified as good. Lower quality of evidence manikin studies were rated as fair or poor. Studies were further classified according to whether they were supportive, neutral or opposing regarding the alternative training method.[17]

3. Results (Table 1)

3.1 Instructor professional background

Our review found 2 studies which examined the background of course instructor and its impact on AED skill performance. Castren conducted a non-randomised study with concurrent controls during which participants were split into two groups to be taught by either lay instructors or instructors who were health care professionals. [18] Their BLS and AED skills were then tested in an objective structures clinical examination (OSCE) 2-3 weeks after training session. Training format was ERC recommended 4 hour course with classroom teaching and hands on practice. AED skill score was not analyzed separately but the study found no significant difference between combined BLS/AED OSCE test score. In a similar study, Xanthos conducted a randomized controlled trial during which 108 nurses were randomized to AED training by either a doctor or nurse instructor. Skill and knowledge retention was measured in a written test and OSCE conducted 1 month after initial training.[19] There was no difference found in the written test, however participants taught by nurses outperformed those taught by doctors in all 7 domains of the OSCE assessment.

3.2 Self directed learning

Self directed learning had the advantage that users can access training in their own time. Copies of training program can be distributed to multiple users. No instructors need to be present, driving the training costs down. Our search reviewed studies which examined self instruction by computer, video and poster.

3.2.1 Computer based learning

De Vries group carried out a pilot study to examine the effectiveness of a web-based BLS / AED self-training program which included theory, scenario training and self-testing, but without practice on a manikin, or any instructor input amongst 16 lay persons.[20] All tested participants performed the assessed skills in AED use correctly but BLS skills of opening airway, ventilations and chest compression depth and rate were performed poorly. The study found no association between the time a participant spent on-line and the quality of performance. The group concluded that it is possible to train people in AED skills using a micro-simulation web-based interactive program and without any practice on a manikin. A non-randomised study by Moule used concurrent controls in which 83 mental health staff were allocated to classroom teaching (2.5 hr lecture, n=55) or e-learning (3 hr access plus one hour manikin practice, n=22) and asked to complete a pre- and post-test questionnaire on AED use and a standardized scenario for BLS performance.[21] The study found that e-learning group was faster to give the first shock and no difference was found for safety performance. Electrode pad placement, however, was poor for both groups. Reder carried out a cluster randomized study of high school students, comparing skill performance after (1) interactive computer learning (2) interactive computer learning plus instructor led practical training (3) video based learning plus instructor led practical training (4) no training.[22] All 4 groups scored higher than 80% for key AED actions with some training (groups1-3) was better than no training (group 4) for BLS/AED skills. Of note, hands-on practice (groups 2 & 3) led to enhanced students' performance (correct AED pad placement and CPR actions) compared to computer training only (group 1). Jerin et al compared AED skill maintenance in emergency medical technicians (EMTs) during quarterly AED skill refresher training.[23] Participants were allocated according to shift patterns to one of 3 groups. Two groups combined computer assisted learning with instructor facilitated learning whilst the control group involved instructor based training only. There were no differences found between training groups in the increase in performance scores.

3.2.2 Video learning

A study by Roppolo randomized 270 airline staff to traditional instructor led training (3 hours) or a 30 min video self learning 'watch-while-you-practice' course which includes manikin CPR practice, verbal discussion of AED but no practical AED use).

[24] Performance following 30-min training was equivalent to the multi-hour Heartsaver-Automated External Defibrillator training in all measurements, both immediately and 6 months after training. At 6 months, 84% of the 30-min training group was judged, overall, to perform cardiopulmonary resuscitation adequately with 93% performing chest compressions adequately and 93% with correct AED skills. The investigators conjectured that the use of an AED is mostly a cognitive skill and that this would be amenable to video or internet training, resulting in better initial performance and a longer retention of skills as compared to the traditional instructor-led training course which emphasizes the psychomotor aspects of AED use. The implication from this is that cognitive training and device driven instructions are more important to initial and long term performance than psychomotor training when using a device such as an AED. Meischke's group targeted AED training to the elderly and randomized 210 senior citizens (average age 71) to 45 minute video or instructor led training.[25] Their study found instructor led group were slightly faster in time to first shock at both immediate evaluations and at 3 months (average time differences of <20 seconds). However, skill performance showed marked deterioration with time in both groups.

A study by Mancini compared a self directed DVD course with un-supervised manikin practice (CPR Anytime) with DVD instructions and practice manikin, against a traditional instructor-led course. [26] Participants were randomized according to group size and in blocks. The self directed group performed skills less well than the instructor led group (lower scores for: calling 911, delivering chest compressions of adequate depth and clearing the victim to analyse and shock). It was noted that these points were not covered in enough detail in the DVD and corrections were made subsequently to the teaching DVD. Unfortunately, the study was not repeated after the improvements in DVD content. Opposing evidence was also found by de Vries and his colleagues when they evaluated self directed BLS and AED training using DVD when compared with instructor led training.[27] 396 laypersons participated in a prospective, randomised trial with non-inferiority design. Participants were divided into 4 groups: DVD training only (2.5min), DVD skill training with personal manikin (4.5min), DVD scenario training with personal manikin (9min) and 90 minute instructor led training. Participants were tested immediately after training and at a

retest 2 months post training. Their results suggest that all 3 DVD training methods were inferior to instructor led training in AED performance. The addition of scenario training improved performances in DVD training group but remained inferior to instructor led group. Overall, test scores improved on retest except for correct placement of pads. In contrast to other studies, the authors did not prompt the use of AED during testing and as a result, a significant number of participants failed the tests because they did not use the AED during testing.

3.2.3 Poster instruction

A study by De Vries examined the efficacy of self directed learning using posters and potential cost savings in AED use. [28] The randomized controlled trial used BLS trained nurses to compare self directed training (with a poster and manikin practice) with traditional instructor training. There was no significant difference in AED performance found between the groups. If poster self-training were to be used instead of instructor-based courses, it was calculated that there would be a saving in costs of up to €6 for each nurse trained.

3.3 Minimal training / No Training

Our search reviewed studies which examined the performance of users with shorter training courses, brief training or even with no training. Kelley et al examined learning outcomes following a condensed 1 hour BLS/AED course amongst thirty-three 8th grade students.[29] Initial skills assessment demonstrated that 29 out of 33 (87.8%) students were proficient at BLS/AED following the 1 hour course. Four week later 28 out of 33 (84.8%) students demonstrated skill retention in similar scenario testing. Students also showed improvement in written knowledge regarding AED use as shown by scores on an AHA based written exam (60.9% versus 77.3%; $p < 0.001$). However, there was no control group to compare with in this study. Andresen group compared 2 hour CPR/AED training in layperson to 4 hour and 7 hour training in a randomized controlled trial.[30] No difference was found in proportion of participants able to deliver a shock within 90 seconds at immediate testing or at 6 and 12 month retention (Immediate: p=0.194, 6 month: p= 0.265, 12 month: p=0.845). Looking at other AED skills tested, 7hr group performed significantly better at immediate testing of calling the correct emergency number, describing the

scenario and pad placement (7hr: 96%, 4hr: 94%, 2hr: 92%, p<0.001), this advantage was no longer evident when skill retention was tested at 6 and 12 months.

Mitchell et al examined the effect of three types of brief training on the use of automatic external defibrillators (AEDs) by 43 lay users.[31] Lay users were divided into three groups: an exposure training group read an article about AEDs that provided no operational instructions; a low-training group inspected the AED and read the operating instructions but was given no practice; and a high-training group watched a training video and performed a mock resuscitation using the AED but no manikin. After 2 weeks, participants were asked to perform a simulated AED resuscitation on a manikin. The results showed that most participants in each training group met minimum criteria of acceptable performance during the simulated manikin resuscitation. Time to first shock was set at 150 seconds and 92.3% of exposure only group and all participants in low and high training groups performed first shock within an acceptable time, however, exposure group was slower (107secs) than low and high training group (73 seconds and 86 seconds respectively). Training had no significant impact on correct pad placement (p>0.08) but more training decreased errors by participants (1.43 in exposure group, 0.67 in low training and 0.31 in high training). Their study concluded that although users with exposure only and no training were able to adequately use the AED, additional brief training improved user time to first shock. A study by Gundry compared AED use by untrained children with trained paramedics using mock cardiac arrest scenario.[32] Mean time to defibrillation was 90+/-14 seconds (range, 69-111 seconds) for the children and 67+/-10 seconds (range, 50-87 seconds) for the paramedics (P<0.0001). Electrode pad placement and safety was acceptable for all subjects. The study found that the differences between the groups were small, considering that children were untrained first-time users.

Beckers group compared AED use by medical students before and after a 15 min lecture.[33] Time to first shock decreased significantly from 81.2 ± 19.2 sec to 56.8 ± 9.9s; p<0.01 with minimal theoretical training. Although brief training shortens time to first shock, 94.1% of students were able to deliver a shock safely within an acceptable time even before training. Two types of defibrillators were used, with

semi-automatic AED requiring the users to press the shock button and automatic AED delivering a shock automatically after 21 seconds. Their results showed that semi-automatic AED was easier and quicker to use than an automatic defibrillator (before training: 77.5 ± 20.5 seconds versus 85.2 ± 17 seconds, P ≤ 0.01; after training: 55 ± 10.3 seconds versus 59.6 ± 9.6 seconds, P ≤ 0.01). A further study by the same group confirmed these findings with 96.6% of participants able to deliver a shock safely with no instructions. Skill retention after brief (15 minute) training remained high at 6 month follow up.[34]

Mattei et al investigated whether nurses and physiotherapists can use an AED without prior training and found all untrained subjects could deliver a shock with an AED in 68.89±29.2 seconds (time ±S.D., range, 40-169 seconds).[35] However, they also found that most participants failed to position the pads correctly (53%) or follow correct safety procedures (67%). After a standard 6 hour training session, the time to deliver a shock improved significantly to 48.59±5.5 seconds (range, 41-61 seconds, P<0.01) and all subjects placed the pads correctly and followed a safe defibrillation procedure. The authors concluded that nurses and physiotherapists, with no previous AED training, can deliver a shock with an AED within a reasonable time but training improves speed of shock delivery, correct pad placement and safety.

4. Discussion

There is little evidence to show that a particular training method is best for AED users in terms of knowledge and skill acquisition and retention and actual AED use. Current courses differ in length, instructor to candidate ratio, format and hands on practice depending on the prior experience and background (layperson or healthcare providers) of the target audience. The course format should be tailored to the needs of the audience: with more emphasis given to awareness of benefits of early defibrillation and minimal risks to rescuers for layperson in the out of hospital setting, and brief training to focus on correct pad placement and minimising delays in defibrillating for healthcare professionals who are already familiar with defibrillation.

This review has identified evidence to support training by layperson instructors. There is also evidence to support the use of alternative training methods in AED training but only one of the studies was designed as a non-inferiority study. Of note,

the alternative training methods described in the studies were non-standardised and quality of the teaching as a result could be variable. Alternative methods of AED training may offer an opportunity for comparable outcomes at a considerably lower cost to the individual provider, the sponsoring institution and the healthcare environment as a whole. The optimal interval between refresher training is currently unknown but maybe as frequent as three to seven months[36-38] with cardiopulmonary resuscitation skills such as effective chest compressions and ventilation decay rapidly over time[38, 39] but AED skills are retained better.[30, 34, 37] The flexibility and increased capacity of novel training methods such as e-learning may prove popular both with teachers and learners but may not suit all learning styles and needs.[40]

Studies which examined minimal training and no training showed that AEDs can be used without previous training. Some researchers have even suggested that the use of AED is intuitive and the cost of training could be diverted to other resources such as CPR training.[34, 37, 41] Other researchers have recommended that AED implementation alone was advantageous and facilitated by not including CPR training.[3, 42, 43] However, even brief training can be helpful in improving speed of shock delivery and electrode pad placement.[31, 35] Guidelines that were recently released by International Liaison Committee on Resuscitation and Resuscitation Council UK have both reiterated the fact that AED can be used safely and effectively by laypeople without previous training.[15,44]

Further development of device features such as time to power on, guidance of pad placement and initiation of CPR should concentrate on usability and suitability to laypeople's needs.[45] Many manufacturers provide product specific electrode to defibrillator connectors which requires rescuer to remove pads and disconnect when transferred to different defibrillator. Manufacturers should be encouraged to collaborate in developing universal connectors to minimise disruption and waste.[4] AED technology is still evolving with the development of rhythm analysis whilst cardiopulmonary resuscitation is on-going and waveform analysis for calculating optimal time for shock delivery on the horizon. [4] The possibility of AEDs providing real time feedback for quality of chest compressions[46, 47] will further reinforce its role in both basic and advanced life support.

There is still much work to be done is making AEDs truly accessible. In 1985, Cummins et al identified, in a landmark paper, the need for AED resuscitation, the challenges of implementation and the training, psychological barriers to be overcome if recovery from out of hospital cardiac arrest was to be successful. Twenty five years later, evidence from studies demonstrated that we are still only partway to answering that call. [48] A recent survey on AEDs revealed that AED use was restricted to trained responders only in 4 out of 36 European countries. Only 7 countries have positive legislations to permit AED use by layperson while in the remaining 17 permission is inferred by absence of restrictions.[49]

Another area of informative research is how to break down the public's perceived barriers of AED use and whether training could reduce reluctance in its use. A study by Taniguchi explored the attitudes toward AEDs in high school teachers, students, EMTs and medical students in Ishikawa, Japan. Their results revealed that majority of layperson did not know what AEDs are indicated for with only 15% of students and 44% of teachers with the knowledge. More than 70% of the 3328 participants would not defibrillate because they do not know what an AED is and or how to use an AED. 5% of laypeople declined due to fear of legal liability.[50] Similar findings was obtained by Lubin who found that awareness of legal protection could increase the proportion of people willing to use the AED from 71% to 84% and training could increase AED use further, up to 91%.[51]

The recent introduction of an international universal AED sign should enable effortless location and recognition of AED, leading to its rapid deployment.[52] By improving public knowledge and reinforcing that AEDs can be used safely and reliably will encourage their use by laypeople, thereby making AEDs truly accessible to all.

5. Conclusion and recommendation

This review provides good evidence to support alternative methods of AED training including lay instructors, self directed learning (web, video, poster) and brief training. There is also evidence to support that no training is needed for AED use. Brief training can be helpful in improving speed of shock delivery and electrode pad placement. Features of AED can have an impact on its use and further research

should be directed to making devices user-friendly and robust to untrained layperson.

Disclaimer

This review includes information on resuscitation questions developed through the C2010 Consensus on Science and Treatment Recommendations process, managed by the International Liaison Committee on Resuscitation (http://www.americanheart.org/ILCOR). The questions were developed by ILCOR Task Forces, using strict conflict of interest guidelines. In general, each question was assigned to two experts to complete a detailed structured review of the literature, and complete a detailed worksheet. Worksheets are discussed at ILCOR meetings to reach consensus and will be published in 2010 as the Consensus on Science and Treatment Recommendations (CoSTR). The conclusions published in the final CoSTR consensus document may differ from the conclusions of in this review because the CoSTR consensus will reflect input from other worksheet authors and discussants at the conference, and will take into consideration implementation and feasibility issues as well as new relevant research.

Conflict of interests

JY and DO declare no conflict of interests. GDP and JS are editors of Resuscitation Journal. JS is Chair of Resuscitation Council UK and Co-chair of Education, Implementation, Teams, International Liaison Committee on Resuscitation (ILCOR).

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Legend for Table

Table 1 Table illustrating included studies (only AED performance related evidence is included). LOE stands for level of evidence. Groups: L= laypersons, H= healthcare professionals.