



Comparison of ease of use of three automated external defibrillators by untrained lay people

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Abstract

The use of automated external defibrillators (AED) by lay people has the potential to markedly increase survival from community cardiac arrest. Wider public use of AEDs requires units that can be operated safely and effectively by people with minimal or no training. This study compares the use of three AEDs by untrained lay people regarding ease-of-use, safety, pad positioning and time to defibrillation. 24 subjects with no prior exposure to the use of AEDs were asked to perform simulated defibrillation on a manikin using three defibrillators: Zoll AEDPlus, Medtronic Physio-Control LifePak CR Plus and Philips/Laerdal HeartStart OnSite Defibrillator. Subjects' performance were videotaped and reviewed for time to defibrillate, pad positioning and safety. Subjects were asked to rate the three units in terms of ease-of-use. Average times to first shock were 74.8 s for the Physio-Control, 83.0 s for the Laerdal and 153.4 s for the Zoll defibrillator. Pad positioning was scored as correct in 23/24 Laerdal trials, 19/24 Physio-Control trials and 14/24 Zoll trials. 23 out of the 24 subjects rated the Zoll most difficult to use. All subjects safely stayed clear of the unit when required. The majority of subjects safely and effectively delivered defibrillating shocks without any prior training and within quite acceptable times. Untrained subjects find the Physio-Control and Laerdal Defibrillator easier to use than the Zoll device. Features of AED design that improved ease of use are discussed.

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Keywords: Automated external defibrillator; Resuscitation; Sudden cardiac death

Resumo

A utilização de Desfibrilhadores Automáticos Externos (AED) por leigos tem o potencial de aumentar, de forma marcada, a probabilidade de sobrevivência pós paragem cardíaca na comunidade. Para que esta utilização dos AEDs pelo público seja alargada são necessários aparelhos que possam ser manipulados com segurança e eficácia por pessoas com treino mínimo ou mesmo sem treino nenhum. Este estudo estuda a utilização de três AEDs por leigos não treinados, comparando a: facilidade de utilização, segurança, colocação das pás e tempo para desfibrilhar. Pediu-se a 24 indivíduos sem qualquer experiência prévia na utilização dos AEDs para realizarem desfibrilhação simulada num manequim utilizando três desfibrilhadores: Zoll AEDPlus, Medtronic Physio-Control LifePak CR Plus and Philips/Laerdal HeartStart OnSite Defibrillator. O desempenho destes indivíduos foi filmado e avaliado relativamente ao tempo para desfibrilhar, posição das pás e segurança. Foi-lhes pedido que classificassem as três unidades relativamente à facilidade de utilização. O tempo médio para o primeiro choque foi 74.8 s para o desfibrilhador Physio-Control, 83.0 s para o Laerdal e 153.4 s para o Zoll. A posição das pás foi classificada como correcta em 23/24 ensaios Laerdal, 19/24 Physio-Control e 14/24 Zoll. 23 dos 24 indivíduos referiu que o Zoll era o mais difícil de utilizar. Todos os sujeitos permaneceram em segurança, afastados da unidade, quando foi necessário. A maioria dos indivíduos sem qualquer treino prévio, administrou a desfibrilhação em segurança e com eficácia e dentro de um tempo bastante aceitável. Indivíduos não treinados consideraram o desfibrilhador Physio-Control e o Laerdal mais fáceis de utilizar que o Zoll. São examinadas as características do desenho do AED que melhoram a facilidade da sua utilização.

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Palavras chave: Desfibrilhação Automática Externa; Reanimação; Morte cardíaca Súbita

Resumen

El uso de desfibriladores automáticos externos (AED) por personal no entrenado tiene el potencial de aumentar marcadamente la sobrevida del paro cardíaco en la comunidad. El uso público mas amplio de AEDs requiere unidades que puedan ser operados con seguridad y efectivamente por personas sin entrenamiento o con entrenamiento mínimo. Este estudio compara el uso de tres AEDs por personas sin entrenamiento con respecto a facilidad de uso, seguridad, posicionamiento de electrodos y tiempo hasta la desfibrilación. Se solicitó a 24 sujetos sin previa exposición al uso de AEDs que realizaran una desfibrilación simulada en un maniquí usando tres distintos desfibriladores: ZollAEDPlus, Medtronic Physio-Control LifePak CR Plus y el Philips/Laerdal HeartStart Onsite Desfibrillator. El desempeño de los sujetos fue filmado en video y se revisó el tiempo a desfibrilación, posición de electrodos y seguridad. Se solicito a los sujetos que catalogaran las tres unidades en términos de facilidad de utilización. Los tiempos promedio a la primera descarga fueron 74.8s para el Physio-Control, 83.0s para el Laerdal, y 153.4 para el Zoll. Se consideró ubicación adecuada de electrodos en 23/24 intentos para el Laerdal, 19/24 para el Physio-Control y 14/24 para el Zoll. 23 de 24 sujetos tasaron el Zoll como el mas difícil de usar. Todos los sujetos se mantuvieron seguros sin contacto con la unidad cuando así se requería. La mayoría de los sujetos entregaron descargas en forma efectiva y segura dentro de tiempos aceptables y sin entrenamiento previo. Sujetos sin entrenamiento encuentran mas fáciles de usar las unidades de Laerdal y de Physio-Control que la de Zoll. Se discuten aspectos del diseño de los AED que mejoran la facilidad de utilización.

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Palabras clave: Desfibrilador automático externo (DAE); Resucitación; Reanimación; Muerte súbita de origen cardíaco

1. Introduction

Recent studies have demonstrated significant increases in survival rates achieved by deployment of automated external defibrillators (AEDs) in a range of settings including casinos [1] aeroplanes [2] and in the hands of groups such as police officers [3].

While these studies support moves to increase the availability of AEDs to the general public, their wider use would only be possible if they can be shown to be very easy and safe to use by subjects with minimal or no training. A recent study of sixth-grade school children, completely unpracticed in AED use, demonstrated that AEDs can be used safely even in naïve users, with times-to-shock that would still be quite acceptable for first responders [4].

To overcome possible problems with safety and effective operation by the lay public, AED use must be intuitive. This requires a simple design, with clear, unambiguous instruction. The AED must be easy to activate and allow for rapid delivery of a shock.

With the lay public in mind, a number of manufacturers have developed AEDs designed to be very simple to use. There are, however, no studies comparing the use of different models of AEDs or looking at those features that improve ease of use. The current study aims to compare three newly developed AEDs; the Zoll AED-Plus, Medtronics Physio-control Lifepak CR Plus and Philips/Laerdal HeartStart Onsite Defibrillator in terms of their ease of use, safety, pad positioning and time to defibrillation by lay people who are completely untrained (Figs. 1–3).

2. Methods

We studied 24 subjects: seven men and 17 women with an age range of 18–46 years. None of the subjects had any prior experience with defibrillators and had not

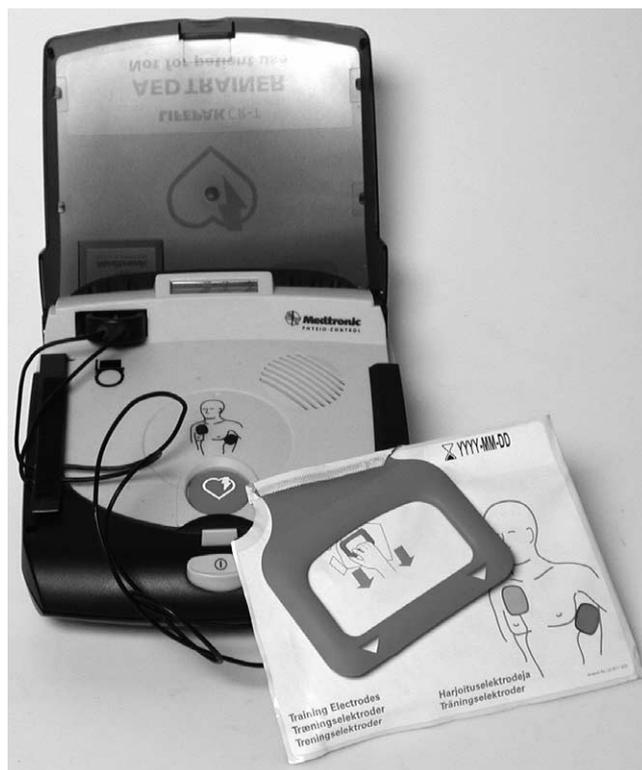


Fig. 1. Medtronic Physio-Control LifePak CRPlus defibrillator with lid open showing electrode pads.



Fig. 2. Zoll AEDPlus defibrillator with lid removed and CPR-D pads.



Fig. 3. Philips/Laerdal HeartStart OnSite defibrillator.

received basic life support training within the previous 5 years. The 24 subjects were randomly allocated to receive the devices using a Latin-square design, such that four subjects received each of the possible six orders.

3. Equipment

Automated external defibrillators:

- 1) Medtronic Physio-control Lifepak CR plus (Fig. 1);
- 2) Zoll AEDPlus with Zoll CPR-D pads (Fig. 2);

- 3) Philips/Laerdal HeartStart Onsite Defibrillator (Fig. 3).

4. Protocol

The subjects were instructed that they would be required to pretend to perform life saving first aid on a manikin. They were shown the AED and told that it was a device that could give an electric shock to a person's chest and that they would need to follow its instruction (Table 1) in order to restart the manikin's heart, and to do so as quickly as possible.

The manikin (Laerdal Resusci-Anne) was placed supine in the middle of the room dressed in a zippered jacket. The AED was placed along side the mannequin and left in the stand-by mode. A video camera and operator were positioned to one side of the room and the examiner read the subject their instructions at the door of the room and was then able to use the remote control of the AED when necessary. The trial was stopped when a shock had been delivered, or at 4 min, whichever came first.

All attempts were videotaped and from the videotapes we determined time required to defibrillate the manikin, correct pad placement and safety. In addition, the subjects were asked to rate the three units from best to worst in terms of ease of use.

The right sided pad was scored as correctly placed if at least one third of the pad was applied to an area circumscribed by the clavicle superiorly, nipple line inferiorly, anterior axillary line laterally and right sternal margin medially. The left pad was scored as correctly placed if at least one third of the pad was applied to an area circumscribed by the nipple line superiorly, costal margin inferiorly, mid-clavicular line medially and mid-axillary line laterally.

Table 1
AED voice prompts

	Physio-Control LifePak CR Plus	Philips/Laerdal HeartStart 1	Zoll AED Plus
AED self check	–	–	Unit OK
Initial assessment	–	–	Stay calm Check responsiveness
Help	Call for help now	–	Call for help Stay calm Check responsiveness
Repeat help	–	–	Call for help
Airway	–	–	Open airway
Breathing	–	–	Check for breathing. Give two breaths
Circulation	–	–	Check circulation
Expose chest	Remove clothing from chest	Begin by removing all clothing from the patients chest—cut clothing if needed	–
Access electrodes	Pull red handle to open bag	When patients chest is bare remove protective cover and take out white adhesive pads	–
Attach electrodes	Peel each pad off blue plastic and apply pads to exposed chest	Look carefully at the pictures on the white adhesive pads. Peel one pad from the yellow plastic liner Place pad exactly as shown in the picture. Press firmly to patient's bare skin When the first pad is in place, look carefully at the picture on the second pad. Peel the second pad from the yellow plastic liner. Place pad exactly as shown in the picture. Press firmly to patients bare skin	Attach electrode pads
Safety	Do not touch patient	No one should touch the patient. Analyzing	Do not touch patient, analyzing
	Evaluating heart rhythm	No one should touch the patient. Analyzing	
Shock advised	Stand by preparing to shock	Shock advised	Treatment advised
Additional safety	Everyone clear	–	Do not touch patient
Deliver shock	Press flashing button	Press the flashing orange button now	Press treatment button

The procedure was recorded as safe if the subject remained clear of the manikin (i.e. was not in contact with the manikin) during delivery of the defibrillating shock.

5. Results

24 lay people performed simulated defibrillation on the manikin using the three AEDs. These results are summarized in Table 2. The mean time to first shock for the Physio-Control was 74.8 s (range 61–90 s), the

Laerdal had an average of 83.0 s (range 54–111 s) and the Zoll had an average time to first shock of 153.4 s (range 92–240 s). The differences in times between the three units were statistically significant (P -value < 0.05).

There was no statistically significant difference between the Laerdal and the Physio-Control in terms of subject preference, but a significant preference for either of these units over the Zoll was expressed. The Zoll was rated the most difficult to use by 23 out of the 24 participants.

Electrode pad placement was scored as incorrect in one out of 24 Laerdal trials, five out of 24 Physio-

Table 2
Summary of results

	Physio-Control LifePak CR Plus	Philips/Laerdal HeartStart 1	Zoll AEDPlus
Time to defibrillate	75 (8)	83 (15)	153 (56)
Incorrect electrode placement	5	1	10
Failed to deliver shock	0	0	6
Preference	1.5	1.4	3.0

Mean (S.D.) time to defibrillate in seconds, the number of subjects who placed the electrode pads incompletely, the number who failed to deliver any type of shock, and the mean rating of the device, from first to third are given for each of the three AEDs.

Table 3
Summary of order effect

	Laerdal	Zoll	Physio-Control
Time to defibrillate	97	170	75
Incorrect electrode placement	0/4	1/4	0/4
	Laerdal	Physio-Control	Zoll
Time to defibrillate	82	73	111
Incorrect electrode placement	0/4	0/4	0/4
	Physio-Control	Zoll	Laerdal
Time to defibrillate	80	114	74
Incorrect electrode placement	2/4	2/4	1/4
	Physio-Control	Laerdal	Zoll
Time to defibrillate	81	71	140
Incorrect Electrode Placement	2/4	0/4	1/4
	Zoll	Laerdal	Physio-Control
Time to defibrillate	207	100	78
Incorrect electrode placement	4/4	0/4	0/4
	Zoll	Physio-Control	Laerdal
Time to defibrillate	178	65	73
Incorrect electrode placement	2/4	1/4	0/4

Mean time to defibrillate in seconds, and the number of subjects who placed the electrode pads incompletely are given for each type of defibrillator for each of the six possible orders in which subjects received the three devices.

Control trials, and ten out of 24 Zoll trials. In all cases the pad placement errors for the Laerdal and the Physio-Control involved the placement of the pads side by side on the anterior chest without reference to the diagrams on the pads. A variety of errors were seen with the Zoll where ten of the 24 subjects were unable to attach the pads correctly. Electrode pad orientation and positioning were at fault in seven of these ten with several bunching up the two pads and placing them side-by-side on the chest. Several subjects failed to remove the adherent backing of the pads or realize that they were adhesive. In addition to these positioning problems, three subjects placed the Zoll pads over the clothing, four failed to remove the adherent backing and one placed the pad upside-down.

There was an order effect in the study in terms of both electrode positioning and time to defibrillation, which is summarized in Table 3. Those subjects that received the Zoll first made significantly more errors in pad placement (six error out of eight) and these errors were of a more profound nature (three subjects placed pads over the clothing and one subject placed the pads upside-down) than those who had previously used one of the other two models. A similar finding was encountered with the Physio-Control defibrillator where all five electrode placement errors occurred in the 12 subjects who received the unit prior to use of the Laerdal defibrillator.

Defibrillation times were significantly slower on the first attempt for the Physio-Control (8 s slower on first attempt, $P=0.01$, ANOVA) and Zoll devices (59 s slower on first attempt, $P=0.03$ ANOVA), but were not different between attempts for the Laerdal device.

All subjects moved clear of the manikin during the delivery of the defibrillating shock and did not touch the manikin during defibrillation or charging.

6. Discussion

Recent advances in AED technology have made the possibility of public access to defibrillators possible [5]; an initiative advocated by several major international health and government organizations [5–8]. Several studies have demonstrated impressive improvements in survival rates where trained non-medical personnel were given access to defibrillators [1–3,9], but few studies have looked at the use of AEDs by untrained, AED-naïve rescuers [4]. No studies have compared the use of different AEDs by untrained lay subjects and identified those features that may make lay rescuers capable of safely and quickly delivering a shock.

Although the manufacturers of AEDs advocate use by trained personnel, in the current study completely untrained lay people were chosen. The testing of these devices by completely untrained individuals has merit for a number of reasons. Firstly, it is inevitable that with widespread distribution of AEDs they will occasionally be used by untrained people. Secondly, these devices may be used by people who have little recall of their initial training or who have not received frequent retraining. Those features that ensure safe and effective use in untrained subjects are likely to be the same features that ensure safe and effective use in the stressful context of cardiac arrest in trained personnel.

While safe use was demonstrated with all three units in the current study, there were marked differences in

terms of speed, accuracy of pad placement and ease of use. The most difficulties were encountered with the Zoll AED plus unit, and some of these related to the use of the Zoll CPR-D electrode pads, which is a one-piece electrode. It is possible that had we used the traditional type of pads as used with the other two units that some of these difficulties may have been overcome. However, we chose to use the CPR-D pads because these are the default pads shipped with the device, and a significant portion of the difficulties users had with the Zoll unit cannot be attributed solely to this difference in the electrode pads. Some subject had difficulty opening the Zoll unit and activating the on/off switch, which requires 5 s of pressure. The Zoll AED gave no instruction to remove clothing from the victim's chest, and three subjects placed the electrode pads over the manikins clothing. Subjects appeared confused by the icons and indicator lights on the Zoll, often attempting to press these purely visual icons. They were also unsure which button was the "treatment button" on the Zoll AED, and four subjects responded to the prompt to push the treatment button by turning the machine off.

7. CPR prompts

Our study did not examine the effectiveness of the AEDs in instructing people to perform CPR. While the primary function of the AED is to deliver a defibrillating shock, both the Zoll AEDPlus and the Laerdal HeartStart also instruct people in the administration of CPR. Studies have demonstrated that with instruction from EMS dispatchers, untrained individuals can perform CPR adequately and that this may improve survival rates from cardiac arrest [10]. Therefore, instructions from the AED may be highly valuable in aiding the performance of CPR and this is an aspect of their function that needs further study.

8. Study implications

This study lends further support to the concept of lay-public access to defibrillation. The majority of subjects were able to effectively deliver a defibrillating shock and, despite having no training in defibrillation, all subjects moved clear of the manikin and observed the instruction not to touch the mannequin during defibrillation. The times to defibrillate were much faster than would be seen if an off-site defibrillator was required.

The features that improved use by untrained operators included clear, simple, method of activating the unit, and a clear method of delivering the shock. Explicit, clear and unambiguous voice prompts relating

to pad placement, removal of adhesive plastic and a prompt to look at the diagrams on the pads also seems critical as the majority of difficulties within the current study related to pad placement. The study indicates that the HeartStart and LifePak CR are easier to use by untrained subjects than the AEDPlus, and are more suitable for use in public access defibrillation.

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