Evaluation of a new semiautomated external defibrillator technology: a live cases video recording study

Frédéric Maes, Sébastien Marchandise, Laurianne Boileau, Jean-Benoît Le Polain de Waroux, Christophe Scavée

ABSTRACT
Aim To determine the effect of a new automated external defibrillator (AED) system connected by General Packet Radio Service (GPRS) to an external call centre in assisting novices in a sudden cardiac arrest situation.

Method Prospective, interventional study. Layperson volunteers were first asked to complete a survey about their knowledge and ability to give cardiopulmonary resuscitation (CPR) and use an AED. A simulated cardiac arrest scenario using a CPR manikin was then presented to volunteers. A telephone and semi-AED were available in the same room. AED was linked to a call centre, which provided real-time information to ‘bystanders’ and emergency services via GPRS/GPS technology. The scene was videotaped to avoid any interaction with examiners. A standardised check list was used to record correct actions.

Results 85 volunteers completed questionnaires and were recorded. Mean age was 44±16, and 49% were male; 38 (45%) had prior CPR training or felt comfortable intervening in a sudden cardiac arrest victim; 40% felt they could deliver a shock using an AED. During the scenarios, 56 (66%) of the participants used the AED and 53 (62%) successfully delivered an electrical shock. Mean time to defibrillation was 2 min 29 s. Only 24 (28%) participants dialled the correct emergency response number (112); the live-assisted GPRS AED allowed alerted emergency services in 38 other cases. CPR was initiated in 63 (74%) cases, 26 (31%) times without prompting and 37 (44%) times after prompting by the AED.

Conclusions Although knowledge of the general population appears to be inadequate with regard to AED locations and recognition, live-assisted devices with GPS-location may improve emergency care.

BACKGROUND
Despite major advances in the management of cardiac diseases, sudden cardiac arrest (SCA) remains a leading cause of mortality in Europe and North America, with survival rates for out-of-hospital cardiac arrest (OHCA) estimated at <10%.1–2 OHCA survival has not significantly improved over the past 30 years.3 The initial underlying rhythm is considered shockable in >80% of victims (ventricular fibrillation or tachycardia)4–9; early defibrillation, in conjunction with cardiopulmonary resuscitation (CPR), is an effective treatment to improve out-of-hospital survival rates.3–4 When CPR is initiated immediately after collapse, survival rates decrease by 3%/4% per minute of delay. Response time to the scene of cardiac arrest, from patient collapse to emergency medical services (EMS) arrival, is often 7–8 min or longer.7–11 Therefore, bystanders are considered an important link in the ‘chain of survival’.

Automated external defibrillators (AED) were developed in the late 1980s to achieve earlier defibrillation. Advances in AED technology have resulted in a number of deployment strategies, and AEDs are increasingly present in high traffic public locations, such as airports, shopping malls and sports clubs. The availability of such devices, in combination with training of the population to use them, has improved victims’ chances of survival.12–17 In a study of non-medical casino staff trained for CPR and AED use, results showed that CPR was initiated 2.9±2.8 min after SCA recognition, and that time taken for the first security officer to use an AED was 4.4±2.9 min.13 This resulted in a survival rate of 38% and reinforced the importance of strategically expanding community-based AED programmes.

Nevertheless, AEDs are expected to be used by untrained people. Devices can recognise an underlying shockable rhythm, and then recommend the most appropriate therapy: external electric cardioversion and/or CPR. Moreover, some AEDs also provide audible CPR instructions for the layperson via voice prompts, and therefore may improve CPR quality for victims in whom shock is not recommended.18 More recently, AEDs that combine GPRS (General Packet Radio Service) technology have been developed. The data acquired by the AED is transferred in real-time to a remote monitoring centre via a wireless dedicated network. A Global Positioning System (GPS) module is
integrated into the AED and informs the remote centre of the exact AED location when it is activated at the scene of SCA. The device also allows the centre to communicate directly with the rescuer in order to coach him or her through proper CPR maneuvers. The system is intended to improve victim survival, but until now, this new technology had not been prospectively evaluated.

Yet, even if we agree with Caffrey et al.'s\textsuperscript{15} conclusion that the ‘lack of training should not constrain attempts to use a defibrillator in emergency’, it remains unclear whether untrained people are able to successfully use an AED in actual emergencies to positively influence patient outcomes.

**MATERIALS AND METHODS**

**Objectives**

The aim of this study was first, to determine knowledge and attitudes of a general population sample with regard to SCA and public access defibrillation and second, to evaluate the effectiveness of a new live-assisted AED technology with GPRS connection.

**Study design**

This prospective, interventional study was conducted in a general hospital, and the protocol was approved by the local institutional ethical board. Volunteers were randomly selected among visitors in the hospital’s main entrance. A designated room next to the entrance hall was set up for the study. All the volunteers read and signed an informed consent form before beginning the study. During the first stage, participants were given a 19-item questionnaire to assess demographic data, evaluate general knowledge of CPR and AEDs, and estimate willingness to use such a device. During the second stage, they were asked to participate in an experiment that lasted approximately 5 min. The two main investigators conducted all the tests in order to provide consistent and similar information to all participants.

A realistic situation was simulated as if someone witnesses a SCA in the community. Participants were expected to perform CPR and use the AED. Study participants were presented with the following scenario: ‘Imagine that you are alone in the room next door with someone who has just collapsed. This person is unresponsive and appears to have had a cardiac arrest. In the room, you will find some materials to make the situation more realistic. Do your best to quickly help the victim and remember that every second matters. The session is timed. I will tell you when the session starts and stops.’ Participants then entered the room alone while the stopwatch was started.

In the simulation room (See figure 1), a CPR manikin (Resusci Anne Skills Station—Laerdal Medical Corporation, Wappingers Falls, New York, USA) was used as a fake victim, and a semiautomated external defibrillator trainer (Philips Heartstart Onsite), identified with a clear AED wall logo, was placed visibly in the corner of the room. A fixed landline phone was also obviously placed on a table. In another corner of the room, a high-definition camcorder (Sony Model HDR-FX1000E) was set up and connected to a dedicated network that would transmit images to an external laptop computer located in a second room. This configuration allowed the examiners to follow the action without interfering with the volunteers. Video recordings were anonymised and stored on an external hard drive. A team of professionals performed all recording tasks. These video recordings would later allow investigators to accurately analyse each simulation and time each step of the AED checklist according to ACC/AHA guidelines.\textsuperscript{19} Time was limited to 3 min for people who did absolutely nothing, while others were timed until they definitely interrupted their activities.

The AED was linked by GPRS to a 24/24 h remote call-centre, which was specifically activated for the simulation. When the AED was removed by a participant, the AED system instantly alerted the call centre by sending a warning message containing the exact geographic position of the AED being used. The call centre then immediately forwarded the information to emergency services. The AED box contains a subscriber identity module (SIM card), which allows the system to work with a cellular communication network. Therefore, a two-way communication can be established. The call centre operator, who had undergone specific training, could then provide real-time instructions on proper CPR and use of the device.

The manufacturer agreed to provide an AED for free. The call-centre was also available for the time of the study. The company was not involved in any way in our research project.
Study population
Participants were all randomly selected volunteers chosen among general hospital visitors. Exclusion criteria were language barrier and people younger than 12 years old. All participants between 12 and 18 years old had to be accompanied by a parent or legal guardian. Participants were categorised as city dwellers or inhabitants of rural areas. Participants were also classified according to their level of education as follows: (1) secondary education and postsecondary non-tertiary education, (2) short-cycle tertiary education, (3) bachelor, master, doctoral or equivalent. Finally, to determine whether age influenced study results, the overall population was divided a priori in three subgroups: ≤30 years, 31–60 years, and >60 years.

Statistical analysis
Data was initially entered into a Microsoft Excel spreadsheet. All analyses were performed using SPSS V19.0.0 (SPSS, IBM, Chicago, Illinois, USA). Continuous variables were expressed as mean± and compared using the Student t test, while categorical variables were expressed as numbers or percentages and compared using the χ² test. Differences between subgroups were analysed using a one-way analysis of variance followed by a posthoc Games–Howell test. A p value ≤0.05 was considered statistically significant.

RESULTS
Baseline characteristics
Answers of the 85 consecutive volunteers were prospectively recorded. Baseline demographic characteristics and AED-related and CPR-related questionnaire items are shown in table 1. Less than half the volunteers had been trained in CPR or felt they could intervene in a cardiac arrest. Fifty-one (60%) participants attested that they did not feel capable of using an AED in a real-life situation. The major reasons given were: ‘I don’t know how the device works’ (45%), ‘I am too stressed’ (4%), and ‘I am afraid to harm the victim’ (2%).

Results and timings of the different checklist items are summarised in table 2. All data were collected during the test and were ascertained a second time on the basis of video recordings.

Forty-seven (55%) participants tried to call the emergency response services, although only 24 (28%) dialled the correct phone number in Western Europe (112). Among the 23 participants who dialled a wrong number, 17 used the AED, allowing the call centre linked to the device to immediately forward the information to emergency services. The call centre also alerted the EMS 21 other times when participants did not make a phone call at all, but used and activated the device.

In total, CPR was performed in 63 (74%) of the 85 scenarios. CPR was initiated without prompting by the AED 26 (31%) times and 37 (44%) times in accordance with AED secondary instructions.

A total of 56 (66%) participants retrieved the AED device from the corner of the simulation room. Among these, 53 (62%) successfully delivered an electrical shock in a mean time of 149 (62; 313) seconds. By following the AED’s operating instructions, participants achieved a 98.1% success rate. However, only 41 of the 53 (77%) participants were able to deliver an electrical shock in less than 3 min. Interestingly, 25 participants among the 53 (47%) who used the device had stated they did not feel able to use an AED in the pretest questionnaire.

Review of the video confirmed that 15 (18%) of volunteers noticed the device, but did not use it. Six additional participants moved the device, but did not immediately use it. The activated AED then sent a warning message to the call centre, which was connected via the real-time platform. The mean time required to establish vocal contact between the centre and the volunteers was 60±23 s compared with 38±45 s, which is the time for participants to spontaneously contact the emergency services. Among these six participants, one did not employ the AED despite instruction provided by the device. Two other participants attempted to communicate with the ‘voice’, but technical problems with data transmission prevented the operator hearing the participants. The three remaining participants followed the call-centre operator’s advice and successfully delivered an electrical shock. The mean time to defibrillation was greater than 3 min for these participants.

While time to shock delivery was not statistically associated with age, more volunteers in the youngest age group delivered a shock within 3 min (table 3). Among the 5 participants under 18 years old, 4 (80%) successfully used the AED with a mean

<table>
<thead>
<tr>
<th>Questionnaire items</th>
<th>Tested volunteers (n=85)</th>
</tr>
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<tbody>
<tr>
<td>Age (years), mean [min; max]</td>
<td>44 [13; 80]</td>
</tr>
<tr>
<td>Male gender, n (%)</td>
<td>42 (49)</td>
</tr>
<tr>
<td>Level of education, n (%)</td>
<td></td>
</tr>
<tr>
<td>Secondary and postsecondary non-tertiary</td>
<td>40 (47)</td>
</tr>
<tr>
<td>Short cycle tertiary education</td>
<td>30 (35)</td>
</tr>
<tr>
<td>Bachelor, master, doctoral or equivalent</td>
<td>15 (18)</td>
</tr>
<tr>
<td>City dweller, n (%)</td>
<td>55 (65)</td>
</tr>
<tr>
<td>Previous CPR education, n (%)</td>
<td>38 (45)</td>
</tr>
<tr>
<td>Feel able to intervene on a SCA victim, n (%)</td>
<td>38 (45)</td>
</tr>
<tr>
<td>Ever heard about AEDs, n (%)</td>
<td>72 (85)</td>
</tr>
<tr>
<td>Feel able to use an AED, n (%)</td>
<td>34 (40)</td>
</tr>
<tr>
<td>AED logo recognition, n (%)</td>
<td>25 (29)</td>
</tr>
<tr>
<td>Correct emergency response number, n (%)</td>
<td>46 (54)</td>
</tr>
</tbody>
</table>

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<tr>
<th>Items checklist</th>
<th>Tested volunteers (n=85)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phone the emergency response number, n (%)</td>
<td>47 (55)</td>
</tr>
<tr>
<td>Mean time to phone the emergency response number (seconds), mean±SD</td>
<td>38±45</td>
</tr>
<tr>
<td>Get an AED, n (%)</td>
<td>56 (66)</td>
</tr>
<tr>
<td>Mean time to get an AED (seconds), mean±SD</td>
<td>43±32</td>
</tr>
<tr>
<td>Check breathing, n (%)</td>
<td>68 (80)</td>
</tr>
<tr>
<td>Give two breaths, n (%)</td>
<td>63 (74)</td>
</tr>
<tr>
<td>Locate CPR hand, n (%)</td>
<td>64 (75)</td>
</tr>
<tr>
<td>Deliver first cycle of compression, n (%)</td>
<td>64 (75)</td>
</tr>
<tr>
<td>Start a second complete cycle, n (%)</td>
<td>64 (74)</td>
</tr>
<tr>
<td>Turn AED on, n (%)</td>
<td>54 (63)</td>
</tr>
<tr>
<td>Prepare patient’s chest, n (%)</td>
<td>54 (63)</td>
</tr>
<tr>
<td>Place pads correctly, n (%)</td>
<td>53 (62)</td>
</tr>
<tr>
<td>Clear victim to analyse, n (%)</td>
<td>53 (62)</td>
</tr>
<tr>
<td>Clear victim to shock, n (%)</td>
<td>53 (62)</td>
</tr>
<tr>
<td>Shock delivery (press shock button), n (%)</td>
<td>53 (62)</td>
</tr>
<tr>
<td>Mean time to shock delivery (seconds), mean±SD</td>
<td>149±51</td>
</tr>
<tr>
<td>Time to shock delivery &lt;3 min, n (%)</td>
<td>41 (48)</td>
</tr>
<tr>
<td>CPR initiated according to AED instructions, n (%)</td>
<td>37 (44)</td>
</tr>
</tbody>
</table>

AEDs, automated external defibrillators; CPR, cardiopulmonary resuscitation.

Table 2 Results and timings of the evaluation checklist

CPR remains a crucial action in the treatment of SCA. While early defibrillation is advised when an AED is available on a SCA scene, given the low prevalence of such devices in public locations, the probability of finding an AED within proximity of an SCA scene is also low. So, CPR should be initiated first in order to increase the chances of a later successful defibrillation.

Another central issue is that a bystander facing an SCA victim may feel less stressed and more confident in starting chest compression without delay assisted by professionals. The benefit of ‘dispatcher-directed bystander’ CPR has been proven. So, we can hypothesise that this assistance may be helpful also in the use of an AED. Currently, there is no specific strategy or protocol like these in Belgium, but this new AED technology could be the first step and needed to be evaluated.

In line with Taniguchi et al, our study confirmed that a substantial proportion of persons were reluctant to operate an AED. In the majority of cases, their reluctance was the consequence of the lack of knowledge about the AED itself. Nevertheless, during the simulation, many participants who had stated they did not feel able to use an AED in the pretest questionnaire removed the device and turned it on and successfully delivered a shock. This highlights the fact that individuals may be more capable in an SCA situation than they would have thought, partly because AED devices are easier to use than they think.

Our finding that there was no significant association between performance and gender or education level suggests that basic reflexes relative to a stressful situation are independent of these characteristics. This is confirmed by the better results for participants with a previous CPR training, independently of the kind or the time of the training. Younger participants may have obtained better results because they are more comfortable with new technologies and more aware of these critical situations thanks to the internet and television.

Regarding the AED itself, this new technology has the advantage of sending a warning message with the precise geographic location of the device. This reduces the time interval between victim collapse and emergency notification, and creates the contact even if the bystander does not contact the EMS by himself. In our study, the device connected with the call centre more frequently than callers did by dialling the emergency number. The second benefit of this new technology is the live-assistance function. Despite their reluctance to use the device, six participants activated this function simply by moving the AED and three of the participants defibrillated the victim with dispatcher assistance. This meant three additional victims were potentially saved, raising the CPR rate in the study by 6%.

Nevertheless, these scenarios identified some technical problems with the device. In two cases, communication was interrupted due to technical problems with data transmission. We also observed that owing to technical reasons the communication with the call centre is automatically interrupted when the device connected with the call centre is. As a result, the bystander intervention may feel less stressed and more confident in starting chest compression without delay assisted by professionals. The benefit of ‘dispatcher-directed bystander’ CPR has been proven. So, we can hypothesise that this assistance may be helpful also in the use of an AED. Currently, there is no specific strategy or protocol like these in Belgium, but this new AED technology could be the first step and needed to be evaluated.

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Nevertheless, these scenarios identified some technical problems with the device. In two cases, communication was interrupted due to technical problems with data transmission. We also observed that owing to technical reasons the communication with the call centre is automatically interrupted when the device itself is turned on. The call centre operator is then unable to continue the conversation with the bystander. Finally, the integrated speaker’s volume level, which was fixed and not adjustable, was occasionally too low for audibly conveying the operator’s voice. This observation is highly relevant in real-life conditions, where surrounding noise would prevent a good communication.

Although the purpose of this study was not to determine cost-effectiveness of the additional technology (GPRS location, real-time information, and data transmission to emergency services), this will need to be considered. Currently, the cost of classical AEDs varies from US$1300 to US$3000, depending upon device

| Table 3 Results and timings of the evaluation checklist regarding age subgroups |
|---------------------------------|--------|--------|--------|--------|--------|
| Items checklist                  | Age <30 (n=16) | Age 31–60 (n=54) | Age >60 (n=15) | p Value |
| Phone the emergency response number, n (%) | 8 (50) | 32 (59) | 7 (47) | 0.67 |
| Time to phone the emergency response number (seconds), mean±SD | 35±35 | 40±50 | 34±33 | 0.90 |
| Mean time to get an AED, n (%) | 13 (81) | 34 (63) | 9 (60) | 0.30 |
| CPR initiated according to AED protocol like these in Belgium, but this new AED technology could be the first step and needed to be evaluated. |

**DISCUSSION**

To the best of our knowledge, our study is the first to evaluate the efficacy of a new AED model connected by GPRS to an external call centre among untrained volunteers. We found that while less than half the volunteers had prior CPR training, and less than 30% felt capable of delivering a shock using an AED, 74% gave CPR and 62% successfully delivered a shock using the live-assisted AED. Previous studies have demonstrated a lack of knowledge about defibrillation in general population.

However, only one study has evaluated the ability of untrained laypersons to successfully operate an AED in a similar simulation experience. This study was performed in a dental school and showed positive results of training with regard to defibrillation time.

The fifth participant was observed to notice the presence of the device but did not use it. Concerning CPR, the items checklist regarding gender (see online supplementary appendix 3).
features, and AED installation in public locations costs from US $500000 to more than US$2 million quality year of life saved. This new technology costs approximately US$2000/year for 1 device including maintenance as well as a basic training.

Our study has some limitations. As mentioned in the methodology, the primary aim was to evaluate the general population’s knowledge and behaviour regarding SCA victim and public access defibrillation. The various checklist items concerning CPR were considered to only be indicative of the SCA context. Therefore, the preliminary questionnaire did not ask about CPR education (When? How many hours? With or without AED?). However, there is not a generally accepted questionnaire currently available to evaluate public knowledge and attitudes regarding AEDs and CPR.

Another study limitation is the recruitment of volunteers from general hospital visitors, which could select volunteers more knowledgeable about disease than people in the general population. Furthermore, a small number of participants cannot be representative of the global population. Nevertheless, our study sample is representative of the general population in terms of age, sex and level of education. We acknowledge that the impact of stress remains difficult to reproduce and assess under simulation conditions. Moreover, even if AEDs become more widely available, it is unlikely that someone will collapse within proximity of the device. Video recordings confirm that some ‘bystanders’ had their attention attracted by the device lying in a corner of the room. However, knowing that only 29% recognised the AED logo in the pretest questionnaire, in a real situation, they may not have considered using an AED.

CONCLUSION
According to our study results, the general population is not sufficiently informed about AED locations and recognition, essential reflexes such as calling the correct emergency response number are lacking, and using an AED is not yet a consideration that readily comes to mind in an important proportion of people.

In this context, live-assisted devices with GPS-location would provide added value to primary care by reducing delay between collapse and the first medical contact and by increasing the success rate of defibrillation as a result of dispatcher assistance.

Contributors All authors have made substantial contributions to all the following: (1) the conception and design of the study, or acquisition of data, or analysis and interpretation of data, (2) drafting the article or revising it critically for important intellectual content, (3) final approval of the version to be submitted.

Competing interests None.

Patient consent Obtained.

Ethics approval Ethics Committee/Institutional Review Board of the Cliniques Universitaires Saint Luc approval.

Provenance and peer review Not commissioned; externally peer reviewed.

Data sharing statement No additional unpublished data to share.

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Emerg Med J 2015 32: 481-485 originally published online July 31, 2014
doi: 10.1136/emermed-2013-202962

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