



Improvement in timing and effectiveness of external cardiac compressions with a new non-invasive device: the CPR-Ezy

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Abstract

Prompt and effective cardiopulmonary resuscitation (CPR) is the first link in the chain of survival following cardiac arrest. We assessed a new device, the CPR-Ezy™ (Medteq Innovations Pty Ltd., Brisbane, Australia), to aid timing and effectiveness of external cardiac compressions (ECC), by 32 subjects who had prior community-based training in CPR. ECC was performed on a manikin for 4 min by all subjects without and with the device. There was a statistically significant improvement in timing of ECC. Effectiveness of compressions was also improved over the whole time period, especially so in the last minute. We conclude that the CPR-Ezy can improve timing and effectiveness of ECC, and reduce the effects of resuscitator fatigue, in community-trained subjects. © 2002 Elsevier Science Ireland Ltd. All rights reserved.

Keywords: External cardiac compression (ECC); Cardiac arrest; Out-of-hospital CPR; Cardiopulmonary resuscitation (CPR)

1. Introduction

The goal of resuscitation is to improve survival from cardiac arrest [1]. Cardiac arrest outside the hospital setting is less likely to result in death if cardiopulmonary resuscitation (CPR), is applied by a bystander [2]. Prompt initiation of effective CPR to restore circulation and breathing is the first link in the chain of survival, but only a small proportion of eligible cases receive bystander CPR [3].

Observations during CPR training show around 50% of chest compressions to be too shallow, and a proportion do not end each compression with the necessary period of relaxation [4]. External chest compressions (ECC) are potentially injurious and, during training, 46% of lay people and 37% of paramedics applied pressure too low over the liver or to the side over the ribs [4].

Current teaching on the frequency of ECC is based on the International Liaison Committee On Resuscitation Guidelines, which recommends 100 per minute as the optimal rate for ECC [5]. We have assessed a new non-invasive device to determine whether or not it can improve timing and effectiveness of ECC.

2. Description

The CPR-Ezy pad is an easy to use, re-useable device designed to assist in CPR. It has a solid plastic shell measuring 55 × 180 × 50 mm and weighs 260 g. It is powered by a 9 V battery, either lithium or alkaline.

There is a body map on the superior surface of the device, indicating the correct position on the chest to place the device. There is also a marker on the device showing where compressions should be applied. Indicator lights are visible on top of the device, with each light representing an approximate body size of the patient (child, small adult, average adult, large adult). They show the level of pressure generated by each compression. They illuminate with each compression,

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giving continual feedback and guiding the amount of pressure applied by the user throughout the resuscitation. Activation pressures for the lights are (± 5 kg) 'child' 23 kg, 'small adult' 32 kg, 'average adult' 41 kg, 'large adult' 50 kg, 'caution' 54 kg. Adequate release of pressure deactivates the light.

A rate adjustable metronome chimes at 100 beats per minute, indicating the correct rate of compressions. The volume of the chimes is 60 dB at 30 cm from the device. See Fig. 1.

3. Methods

General (non-medical and -nursing) staff at a large inner-city teaching hospital who had been trained in basic life support (CPR) in the community were invited by electronic mail to register their interest in participating in evaluating a new device in CPR. Subject characteristics are listed in Table 1.

Subjects were instructed to perform ECC on a manikin capable of registering timing and effectiveness of compression. The effectiveness of compressions was based on the force generated. We defined an effective compression as one performed in the correct position, achieving the correct amount of force for an average size adult, and being released fully after compression to allow adequate cardiac filling.

ECC were performed for 4 min in a mock representation of two-person CPR. The two-person sequence was chosen because we wanted to focus on the ECC only. The CPR-Ezy also has a mask included for ventilation, but in assessing the CPR-Ezy pad, we felt it was more appropriate to isolate ECC from ventilation. Details of position, timing and effectiveness of compressions was recorded for the entire 4 min and were recorded and

Table 1
Details of study subjects

Study subjects		
Characteristics	Number	Percent
Men	11	34
Women	21	66
Years since CPR course		
Less than one	6	19
One to five	11	34
More than five	5	16
Not specified	10	31

analysed separately for the last minute, to assess the effect of fatigue on effectiveness of ECC.

The following day, the subjects were instructed to perform the same task with the CPR-Ezy device in position. They were given brief verbal instructions, including that the mock patient was an average size adult, but no practice with the device prior to the study.

Data on continuous variables were analysed with paired *t*-tests. Categorical variables were expressed as proportions and searched with the χ^2 -test. All tests were two-tailed and statistically significant differences at the $P < 0.05$ level are indicated with asterisks.

4. Results

4.1. Position of cardiac compressions

Table 2 shows that use of the CPR-Ezy pad results in ECC position being improved in 10/32 subjects (31%), unchanged in 20/32 (62%) and worse in 2/32 (6%),

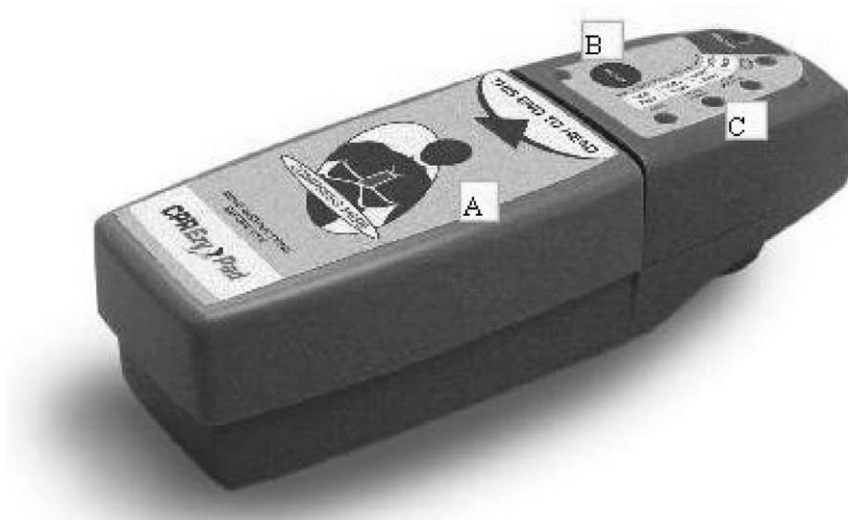


Fig. 1. The CPR-Ezy pad. Illustrated are the hinged compression pad (A), the on/off button (B) and the LED indicator lights (C).

Table 2
Positioning for ECC

Position of ECC	Number of subjects	Percent
Correct both trials	19	59
Incorrect without device; correct with	10	31
Correct without device; incorrect with	2	6
Neither correct	1	3

resulting in a net improvement of position of 25% of subjects ($P < 0.05$).

4.2. Effective compression

The percentage of effective compressions improved significantly using CPR-Ezy at all time intervals ($P < 0.001$) see Fig. 2. This was apparent over the entire 4 min period, but there was a substantial deterioration in the final minute without CPR-Ezy, which did not occur with the device.

4.3. Rate of compression

Fig. 3 shows the rates of compression with and without the CPR-Ezy pad for each subject over the whole 4 min period. Improvement when using the device was maintained throughout the entire test period, but this improvement was more pronounced in the final minute.

Individual rates of compression were subtracted from the recommended rate of 100 compressions per minute to give rate divergence (Table 3). Mean divergence from ideal rate was significantly decreased using the CPR-Ezy device ($P < 0.001$).

5. Discussion

To improve outcome after out of hospital cardiac arrest, it is necessary to initiate CPR early and to perform ECC at the correct depth and at optimal timing [4]. This study has shown that community-trained

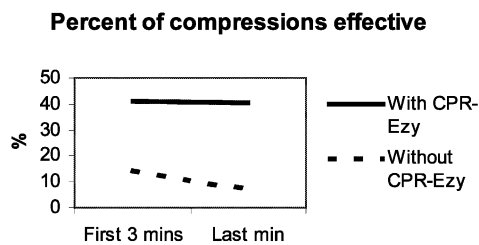


Fig. 2. Percentage of effective compressions. Comparison of the percentage of compressions performed which were effective. Note that the CPR-Ezy improved percentage of effective compressions and there was no deterioration in the fourth minute.

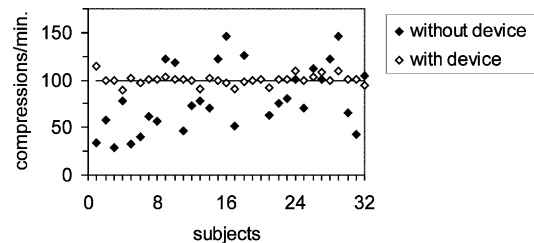


Fig. 3. Compression rate over 4 min.

Table 3
Effectiveness of compressions performed by the same subjects with and without the CPR-Ezy device

Time interval	Percentage compressions effective each minute	
	Without	With device
Entire 4 min	12.8 ± 3.7	42.1 ± 5.2*
First 3 min	14.6 ± 4.3	41.0 ± 5.4*
Last 1 min	7.5 ± 3.1**	40.4 ± 6.2*

Data are mean ± SEM.

subjects can improve the position, rate and effectiveness of ECC.

The point of compression is important in providing an adequate circulation, as well as avoiding injury. The CPR-Ezy raises the level of the rescuer's hands so that pressure is directed over the sternum, and less force is exerted over the ribs. We have demonstrated an improvement in the point of ECC in approximately 25% of subjects. This may translate into a substantial benefit in cardiac output and reduction in injury to patients receiving CPR, but this remains to be evaluated in clinical trials.

There was a striking improvement in the timing of cardiac compressions using the device. Importantly, this was maintained over a sustained period, suggesting that the device helps overcome the effects of fatigue during CPR. This might be achieved using a metronome beside the patient just as effectively, but the other benefits would not be achieved using this approach.

Effectiveness of cardiac compressions is difficult to quantify. We defined an effective compression as one performed in the correct position, achieving the correct amount of force for an average size adult, and being released fully after compression to allow adequate cardiac filling. Over the 4 min period, the percentage of compressions, which were effective, more than trebled, from 12.8 to 42.1%. When combined with an improvement in timing, this is likely to translate into additional improvement in overall effectiveness of CPR. This does not translate into definite improved survival following cardiac arrest, but it shows that the device is not detrimental and may offer some benefit during cardiac arrest. This needs to be addressed in a clinical trial during cardiac arrest before any recommendations

Table 4
Divergence from ideal compression rate

Time interval	Divergence from ideal compression rate	
	Without device	With device
First 3 min	31.3 ± 3.7	3.6 ± 0.8*
Last 1 min	33.9 ± 3.8	6.6 ± 1.3*

Compression rates were subtracted from the optimal rate of 100 per minute and are presented as mean ± SEM.

regarding widespread clinical use of this device can be made.

There are other devices that aim to improve the performance of rescuers during CPR. One such device, the CPR-plus [6], is similar in overall design. The main difference is that CPR-Ezy is self contained, with flashing light and audible beep to indicate correct timing being part of the unit, not separate as in the CPR-plus. This may be important in the often highly charged and stressful situation of a real life cardiac arrest where the two parts of the CPR-plus may become separated. When using the CPR-Ezy is easier to see if the correct amount of force is generated because it has a flashing light, whereas the CPR-plus has a dial which is more difficult to read.

The issue of resuscitator fatigue is an important one, especially in out of hospital arrest where help may not be available immediately, and there may be substantial delays until the arrival of paramedics. In the fourth minute of ECC, the percentage of compressions that were effective dropped to approximately half of that in the first 3 min without the CPR-Ezy, but remained unchanged when using the device (Table 3). This suggests that declines in performance arising from resuscitator fatigue can be ameliorated using this device.

This study is limited in that it explores surrogate markers in a manikin model; further study collecting haemodynamic or outcome data in humans appears to be warranted. Furthermore, there may have been a learning effect from performing CPR on the manikin 1 day and using the CPR-Ezy the next day, which would improve the performance the following day. This could be addressed by randomising the subjects into two

groups, one performing CPR without the device on the 1st day, the other performing it with the device first and then changing over on the 2nd day.

This study assumes that the CPR-Ezy device will be readily available when a cardiac arrest occurs. This may be the case if kept in a first aid kit, at sporting or recreation clubs for example, or in the glove-box of a car, but it may not be ready at hand when a cardiac arrest occurs. Therefore, it can never take the place of formal training in CPR. It does, however, suggest that there may be benefit in using the CPR-Ezy in out of hospital cardiac arrests, in terms of improving timing and effectiveness of ECC, reducing injury from incorrect position of ECC and in overcoming the effects of resuscitator fatigue (Table 4).

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References

- [1] Jude J.R., Kouwenhoven W.B., Knickerbocker G.G.. Cardiac arrest: report on application of external cardiac massage on 188 patients. *J Am Med Assoc* 1961;178:1063–71.
- [2] Eisenberg M.S., Horwood B.T., Cummins R.O., Reynolds-Haertle R., Hearne T.R.. Cardiac arrest and resuscitation: a tale of 29 cities. *Ann Emerg Med* 1990;19:179–86.
- [3] Handley A.J., Bahr J., Baskett P., Bossaert L., Chamberlain D., Dick W., Ekstrom L., Juchems R., Kettler D., Marsden A., Moeschler O., Monsieurs K., Parr M., Petit P., Van Drenth A.. The 1998 European resuscitation Council guidelines for adult single rescuer basic life support. *Resuscitation* 1998;37:67–80.
- [4] Eisenburger P., Safar P.. Life supporting first aid training of the public—review and recommendations. *Resuscitation* 1999;41:3–18.
- [5] The American Heart Association in Collaboration with ILCOR. Guidelines 2000 for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care, *Circulation* 2000;102(suppl I):I-358-70.
- [6] Elding C., Baskett P., Hughes A.. The study of the effectiveness of chest compressions using the CPR-plus. *Resuscitation* 1998;36:169–73.

Portuguese Abstract and Keywords

Reanimação Cardiopulmonar (CPR) imediata e eficaz é o primeiro elo na cadeia de sobrevivência após paragem cardíaca. Avaliámos a utilização de um novo aparelho, o CPR-EzyTM (Medteq Innovations Pty Ltd., Brisbane, Australia) para melhorar a eficácia e o “timing” das compressões cardíacas externas (CCE), por 32 indivíduos que tiveram treino prévio na comunidade em CPR. Todos os indivíduos realizaram CCE, com e sem o aparelho, num manequim durante 4 minutos. Houve uma melhoria estatisticamente significativa no tempo das CCE. A eficácia das compressões foi também melhorando ao longo do tempo, especialmente no último minuto. Os autores concluem que o CPR-Ezy pode melhorar o “timing” e a eficácia das CCE, e reduzir o efeito da fadiga do reanimador, em indivíduos treinados na comunidade.

Palavras chave: Compressão Cardíaca Externa (CCE); Paragem cardíaca; CPR fora do Hospital; Reanimação Cardiopulmonar (CPR).

Spanish Abstract and Keywords

Reanimación cardiopulmonar CPR rápida y efectiva es el primer eslabón en la cadena de supervivencia después de un paro cardíaco. Para ayudar a optimizar los tiempos y la efectividad de las compresiones cardíacas externas (ECC), evaluamos un nuevo equipo, el CPR-Ezy™ (Medteq Innovations Pty Ltd., Brisbane, Australia), por 32 sujetos previamente entrenados en CPR basado en la comunidad. Todos los sujetos realizaron las ECC por 4 minutos en un maniquí con y sin equipo. Hubo una mejoría estadísticamente significativa en los tiempos de ECC. La efectividad de las compresiones también mejoró a lo largo de todo el período de tiempo, especialmente en el último minuto. Concluimos que el CPR-Ezy puede mejorar la efectividad y los tiempos de ECC, y reducir los efectos de la fatiga de los reanimadores, en sujetos entrenados en la comunidad.