Improving the quality of CPR in the community

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ABSTRACT

Bystander cardiopulmonary resuscitation (CPR) is important for survival from out-of-hospital cardiac arrest (OHCA). However, recent research indicates that the quality of CPR is an important and often overlooked factor affecting survival. Individual factors, training, awareness, technique and rescuer fatigue may influence the quality of CPR. Quality components of CPR include rate, ratio, depth and ventilation-compression ratio. The new 2010 CPR guidelines advocate a ratio of compressions to ventilations of 30:2, with a rate of at least 100 compressions per minute. Depth of compression should be at least 5 cm. Rescuers should allow complete recoil of the chest. Locally, limited information is available regarding the quality of CPR being performed for OHCA. Strategies to improve the quality of CPR include research, training, education as well as incorporating appropriate technologies that measure and feedback the quality of CPR. These technologies are at the heart of recent advances, as they now make it feasible to provide routine feedback to rescuers providing CPR, through the integration of feedback devices into training equipment, defibrillators and standalone CPR assist devices.

Keywords: bystander, cardiac arrest, cardiopulmonary resuscitation, community, quality

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INTRODUCTION

Of the approximately 16,000 deaths that occur in Singapore every year, about 23% are from a cardiac cause,[1] some of which will occur suddenly and outside of a hospital. A study conducted from October 2001 to September 2004 found that a total of 2,428 out-of-hospital cardiac arrests (OHCA) occurred in Singapore.[2] The mechanism of death is usually a fatal arrhythmia, most often ventricular tachycardia or fibrillation.[3] Many of these patients would be clinically dead long before they are transported to a hospital. In the chain of survival concept,[4,5] the provision of early bystander cardiopulmonary resuscitation (CPR) in OHCA is important to improve survival in sudden cardiac arrest. There is currently good evidence that indicates the importance of CPR combined with early defibrillation (< 4 mins).[6-9] Survival rates for pre-hospital cardiac arrest vary in published reports, from 2% to over 20% in various cities and countries.[10]

Singapore's Emergency Medical Services (EMS) system is run by the Singapore Civil Defence Force (SCDF), which currently operates 36 ambulances based in 14 fire stations and more than ten fire posts in a single- tier system. Private ambulance operators do not generally convey emergency cases. Singapore EMS is activated by a universal, centralised and enhanced '995' dispatching system run by the SCDF, which utilises a computer-aided dispatch system, medical dispatch protocols, Global Positioning Satellite automatic vehicle locating systems and road traffic monitoring systems. Since 1996, ambulances in Singapore have been manned by specifically trained paramedics. They are able to provide Basic Life Support (BLS) and defibrillation with automated external defibrillators (AED), intravenous adrenaline and saline infusions. They also perform laryngeal mask airway insertion in cardiac arrest.

The Cardiac Arrest and Resuscitation Epidemiology (CARE) study group includes representatives from the six major public hospitals in Singapore, the SCDF, Health Sciences Authority and the Clinical Trials and Epidemiology Research Unit of the Ministry of Health, Singapore. The CARE phase I study, which described the OHCA epidemiology in Singapore,[11] found survival from OHCA in Singapore to be 2.0%. The mean and standard deviation of EMS response time was found to be 10.2 ± 4.3 minutes and that of time from call to defibrillation was 16.7 ± 7.2 minutes. 35.3% of arrests were not witnessed, 54.6% were bystander witnessed and 10.0% were witnessed by EMS personnel. Bystander CPR was present for 20.6% of all cases, and a further 10.0% received immediate CPR from EMS personnel who witnessed the arrest.[11]

QUALITY OF CPR

Previous studies have demonstrated the importance of bystander CPR to survival from OHCA.[7,12] However, recent

Table I. International Liason Committee on Resuscitation recommendations for quality of adult CPR.

	ILCOR 2005[31]	ILCOR 2010[32]
Ventilation rate	8–10/min	No change
Inspiratory time	< 1 sec	No change
Tidal volume	500–600 ml	No change
Compression rate	> 100/min	No change
Compression depth	4–5 cm	> 5 cm
Chest recoil	50% duty cycle complete recoil (compression/ release)	No change
Compression: ventilation ratio	30:2	No change

CPR: cardiopulmonary resuscitation

research has indicated that the quality of CPR is an important but often overlooked factor affecting survival.[13,14] The current International Liaison Committee on Resuscitation (ILCOR) Advanced Cardiac Life Support Guidelines (2005)[15, 16] suggest that the quality of CPR is as important as the presence or absence of bystander CPR.

Several factors may influence the quality of CPR, including individual factors, training, awareness, technique as well as rescuer fatigue. Quality components of CPR include the rate, ratio, depth as well as ventilation-compression ratio. There is good evidence to show that excessive ventilation rates during CPR result in significantly increased intrathoracic pressures and markedly decreased coronary perfusion pressures.[17-19] It is suggested that hyperventilation frequently occurs during CPR, even when performed professional rescuers,[18] and survival rates decrease as a result. The 2005 CPR guidelines[16,20] recommended an inspiratory time of one second, at a rate of 8–10 ventilations per minute. In a patient with an established advanced airway (e.g. endotracheal tube), it is reasonable to deliver ventilations without pausing chest compressions.

Another important factor is the rate of chest compressions and the problem of prolonged interruption of chest compressions during CPR, resulting in less cycle time on chest compression and lower coronary perfusion pressures.[21-24] Studies have shown that the rates of chest compression during CPR are often far less than those recommended.[14,25,26] One study has shown improved haemodynamics in humans with high-frequency CPR (120/min) compared with standard CPR.[27] The depth of compression achieved has also been shown in clinical studies to be often much less than that recommended by CPR[25,28] guidelines. In animal models, the depth of compression was related to better outcomes.[29] Also, incomplete chest recoil has been found to be associated with increased intrathoracic pressure, resulting in decreased coronary and cerebral perfusion.[30]

The local 2006 CPR guidelines[20] advocate a 30:2 ratio of compressions to ventilations, with a rate of 100 compressions per minute. Depth of compression should be at least 4–5 cm. Rescuers should also allow complete recoil of the chest, with a ratio of compression to release of 50%. Table I shows a comparison between the 2005 and 2010 ILCOR guidelines for quality of CPR.[31,32]

Researchers have been using the following parameters to measure the quality of CPR: rate of chest compressions; rate of ventilations; and CPR flow fraction, usually for the first five minutes of resuscitation. The CPR flow fraction and its counterpart, the 'no flow ratio' (NFR), reflect the ratio of compressions to pauses ('no flow') in the CPR cycle.[33] Compression is usually defined as the fraction of time with sub-zero position of the sternum, while 'no flow' is defined as all pauses between compressions longer than 1.5 seconds. The sum of such intervals is then divided by the segment length (e.g. five minutes), from which the NFR can be derived. These research parameters are usually obtained automatically using various software programmes bundled with the latest defibrillators. Locally, there is currently limited information available regarding the quality of CPR being performed for OHCA in Singapore. In the CARE phase I study, bystander CPR was present for 20.6% (103 out of 500) of all cases; however, only 67.0% of these (69 out of 103) were reported to have received CPR with both compression and ventilation. Another 26.2% (27 out of 103) received chest compression only.[11]

Regarding the Emergency Department, a study on the quality of CPR found significant interruptions to CPR with both manual and mechanical CPR.[34] The 'no flow time' (NFT) (defined as the sum of all pauses between compressions longer than 1.5 seconds) during the first five minutes of resuscitation was manual CPR 85 seconds vs. mechanical CPR 104 seconds (difference = 19 seconds; 95% confidence interval [CI] –18 to 56). The NFR, defined as NFT divided by segment length, was manual 0.28 vs. LDB 0.40 (difference = –0.12; 95% CI –0.22 to –0.02).

IMPROVING THE QUALITY OF CPR

Several strategies have been suggested in order to improve the quality of CPR in our community. These include research, training, education and incorporating appropriate technologies that measure and feedback the quality of CPR. These technologies are at the heart of recent advances, as they now make it feasible to provide routine feedback to rescuers providing CPR through

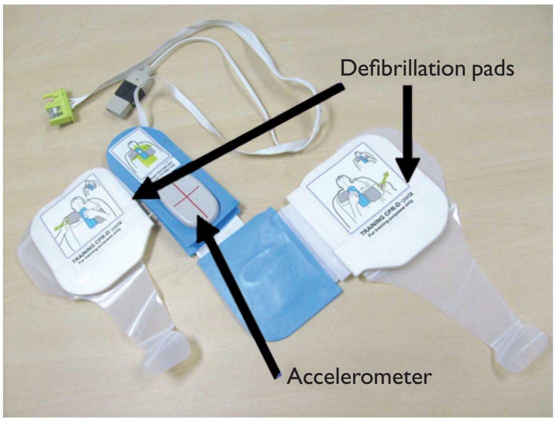

Fig. 1 Photograph shows defibrillator pads incorporating an accelerometer for QCPR feedback (Zoll E series defibrillation pads).

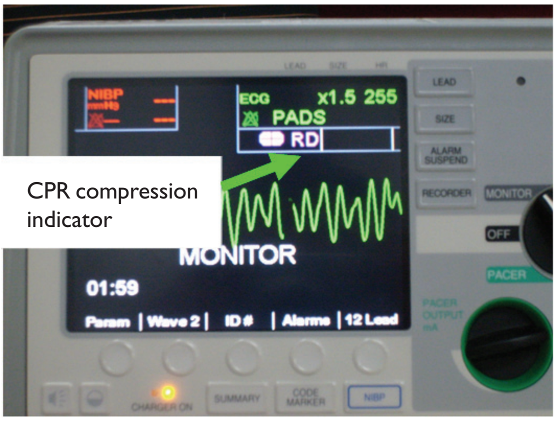

Fig. 2 Defibrillator screen display incorporating QCPR feedback indicators (Zoll E series). When complete filling of the CPR compression indicator has not been achieved due to diminished compression rate or depth, the E Series will display the letter R for rate and/or the letter D for depth to assist the rescuer in determining whether chest compression rate or depth should be increased. When appropriate rate and depth have been achieved, these letters will disappear from the display field. A voice prompt option is also available.

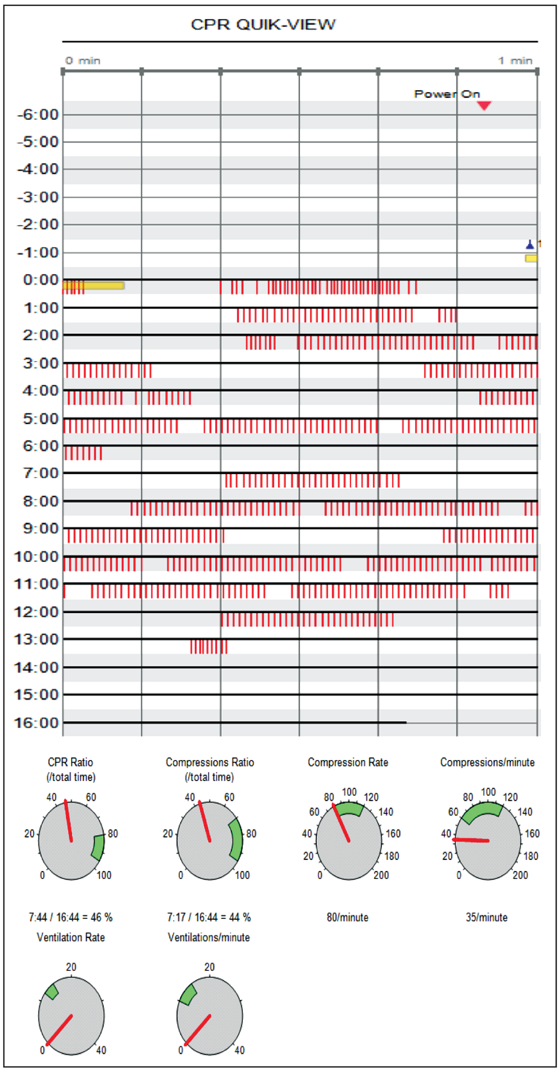

Fig. 3 QCPR feedback showing the number of compressions and ventilations per minute over a period (Medtronic-Physiocontrol Codestat Suite).

integration of feedback devices into training equipment, defibrillators as well as standalone CPR assist devices.

CPR feedback devices have long been incorporated into training manikins used for CPR instruction. These are able to provide feedback to trainees regarding the rate and depth of chest compressions, as well as the rate and volume of ventilations. Training using a manikin equipped with a computer-based voice advisory feedback system has been shown to improve retention of CPR skills.[35] The use of a video recording of a trainee's performance is now an additional tool available for instruction. It cannot be over-emphasised that CPR training centres should keep up-to-date with the latest CPR guidelines and ensure good quality CPR feedback during instruction, so that proper techniques can be learnt and retained.[36] This also applies to healthcare providers as well as public teaching of CPR. This attention to quality also highlights the need for accreditation of CPR training centres and regular audits in order to maintain high standards. It is also important to ensure trainees are kept updated on the latest CPR guidelines through recertification.

More importantly, devices to facilitate real-time feedback to CPR providers are now available. The latest generation of defibrillators utilise accelerometers embedded within chest defibrillation pads to measure the depth and rate of compression, as well as variations in chest impedance that can reflect chest wall movements.[14,25] Fig. 1 shows an example of a device that incorporates an accelerometer, which is located on the sternum, beneath the heel of the hand, while manual compressions are going on. These devices are able to give verbal as well as visual prompts to rescuers performing CPR, and cue the rescuer to speed up, slow down or increase the depth of compressions or ventilations.[37] An example of these visual cues is shown in Fig. 2. Such devices have been shown to improve the quality of CPR for OHCA[33] as well as in-hospital cardiac

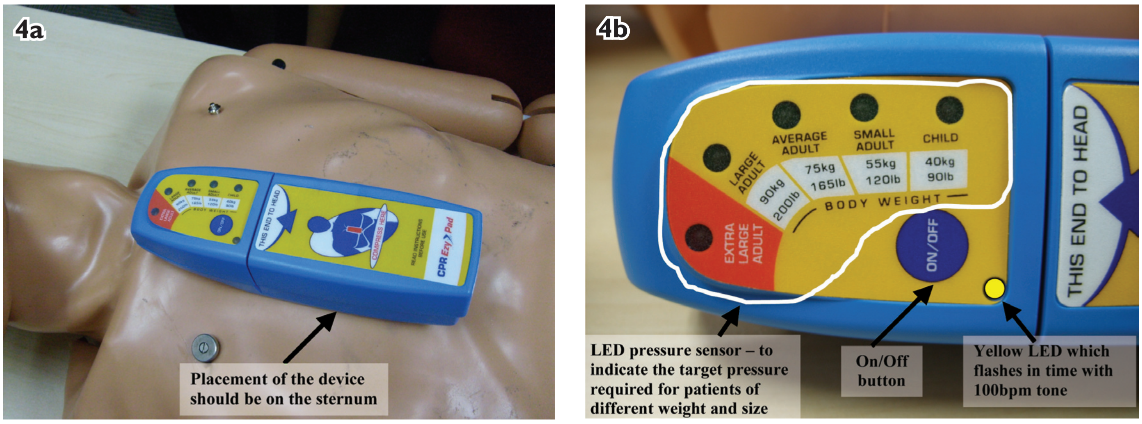

Fig. 4 (a & b) Photographs show a pocket QCPR feedback device for use with manual CPR (CPREZY).

arrest (IHCA).[37] Provision should be made for the gradual upgrading of existing defibrillators to include quality of CPR (QCPR) technology in the hospital and in out-of-hospital settings. Fig. 3 shows an example of the QCPR summary data available from such devices. Small, pocket-sized, standalone devices are also now commercially available to provide rescuers with real-time CPR feedback (Fig. 4). Education of the public will help increase the usage of such devices among lay rescuers.

In the hospital setting, collection of CPR data should become a routine part of hospital quality assurance processes. Adoption of defibrillators using QCPR software will enable routine monitoring, evaluation and feedback to CPR providers from IHCA. For example, the National Registry of Cardiopulmonary Resuscitation (NRCPR) is an American Heart Association (AHA)-sponsored, prospective, multi-site, observational study of in-hospital resuscitation.[38] QCPR data is one of the items routinely collected by study sites.

Good quality research on QCPR in our community is much needed locally in order to identify areas that require intervention. Innovative strategies are needed both to increase the number of trained CPR providers in Singapore as well as the quality of instruction and CPR performed. For example, it has been suggested that widespread video-based CPR instruction may be used as a simple tool to teach CPR,[39] so as to reach a larger group of the population. Others have looked at identifying targeted, high-risk groups for CPR instruction.[40] Another area for implementing QCPR is with dispatcher-assisted CPR.[41] This occurs when the EMS dispatcher is able to give instructions on how to perform CPR to a willing rescuer over the telephone. QCPR technology can now be integrated with dispatcher CPR protocols[42,43] to cue the rescuer as to how many compressions and ventilations to give per minute, as the rescuer counts out with the dispatcher over the telephone. A compression and ventilation rate counter is integrated with the dispatcher's tools on his computer screen. There have been proposals to upgrade Singapore's dispatch centre with this technology.

A more controversial area is the use of chest compression-only CPR (CC-CPR) without ventilations as an alternative to standard CPR for bystanders.[44] Proponents of CC-CPR argue that it overcomes bystander reluctance to do mouth-to-mouth ventilations,[45-53] is simpler to teach[54-56] and may result in fewer interruptions to chest compressions.[21-24] However, there have been controversies regarding the relative effectiveness of CC-CPR.[57-59] Current ILCOR guidelines state that CC-CPR should be encouraged only if the rescuers are unwilling to do airway or breathing manoeuvers, or are untrained in CPR and are thus uncertain about how to perform CPR. These guidelines also recognise the need for more research on the efficacy of CC-CPR.

Evidence from swine models of cardiac arrest suggests that ventilation may not be essential in the initial 12 minutes of resuscitation[23,60] and that oxygen tensions can be maintained above 100 mmHg with only CC-CPR.[61] However, when the animal model was simulated with an obstructed airway, as might often be the case in real-life cardiac arrest, arterial blood was completely desaturated within two minutes.[62] Also, in a human model of cardiac arrest, passive ventilation during CC-CPR was limited in its ability to maintain adequate gas exchange.[58]

Finally, with the development of portable, field-deployable, mechanical CPR devices,[63-65] there is potential to overcome the problems of rescuer fatigue and individual variations in the quality of CPR. More research and development are needed in order to produce cost-effective mechanical CPR devices that can be widely mass produced.

IMPLICATIONS FOR OUR COMMUNITY

We now know that encouraging community bystander CPR by itself is insufficient. More emphasis on QCPR in order to improve survival rates in our community is required. This translates into an important message for community CPR education.[66] Emphasis on QCPR should be incorporated into community CPR training, and also into the training and mindset of CPR instructors. These instructors would be the medium through which good quality practices can be passed on to the providers who would be the eventual lifesavers in the community.

Meanwhile, emphasis should also be placed on improving our community EMS response.[67] This includes continuous quality improvement and research on our EMS dispatch and ambulance services. Efforts should also be made to upgrade and incorporate QCPR technology into defibrillators and other devices used by rescuers. A national registry should be established to monitor the QCPR during both OHCA and IHCA. QCPR data should be collected and used as part of hospital routine quality assurance processes.

The science of resuscitation is constantly evolving as new discoveries emerge. It is inevitable that CPR guidelines will continue to change and be regularly updated and revised. This highlights the importance of having a National Resuscitation Council (NRC) to constantly evaluate the current scientific evidence and adapt the latest knowledge for local use. It also highlights the need for currency and recertification in CPR training. The NRC also has a role in community-wide dissemination of the latest CPR guidelines.

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