Chest compression-only CPR or good quality 30:2 CPR

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ABSTRACT

There is debate as to whether chest compression-only cardiopulmonary resuscitation (CC-CPR) or standard 30:2 CPR should be taught to laypersons. Equivalence in outcomes between standard CPR and CC-CPR has been amply demonstrated in communities with short ambulance response times of about five minutes. Depriving oxygen from a collapsed patient beyond six minutes results in poorer outcomes. Communities with prolonged ambulance travel times have seen improved outcomes with CPR than CC-CPR. While healthcare workers demonstrate a reluctance to perform mouth-to-mouth ventilation, laypersons generally show a willingness to do so. Rescuer fatigue also argues against the use of CC-CPR for more than a few minutes. For communities with relatively long ambulance transport times, the best approach appears to be standard CPR, with emphasis on good quality compression. For dispatcher-assisted CPR, communication issues suggest that CC-CPR is advisable. Public CPR training should include teaching of mouth-to-mouth ventilation alternating with chest compressions.

Keywords: ambulance response times, chest compressions-only, dispatcher-assisted cardiopulmonary resuscitation, rescuer fatigue, standard cardiopulmonary resuscitation

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INTRODUCTION

On March 31, 2008, the American Heart Association (AHA) released an advisory[1] on bystander cardiopulmonary resuscitation (CPR). The statement emphasised that trained and untrained lay rescuers need only provide chest compressions at a rate of 100 per minute until the emergency ambulance team arrives, unless the rescuer is confident in his/her ability to provide mouth-to mouth ventilation. The statement was made based on research that chest compression-only CPR was equivalent to the old CPR standards. Previous CPR guidelines issued in 1990, 1995 and 2000 did not emphasise the importance of quality and rate of chest compressions, or the importance of complete chest wall recoil and the need to minimise interruption of chest compressions. This statement was made in the hope that more members of the public would willingly perform CPR if they could not perform mouth-to-mouth ventilation in the event that they were bystanders to a cardiac arrest event. The call by AHA was made out of concern for the disturbingly low level of bystander CPR in the USA. AHA, however, acknowledged that "chest compression-only CPR may not be suitable for some cases of cardiac arrests such as in infants, and those due to drug overdose, choking, drowning and respiratory arrest". Since then, especially owing to the active media exposure[2-4] by a group of physicians from the state of Arizona, USA, there have been many calls to do away with mouth-to-mouth ventilation and to focus on chest compression-only CPR as a means of increasing bystander CPR rates.

AMBULANCE RESPONSE TIMES

The call by AHA was based mainly on studies in a few localities with relatively short emergency ambulance response times such as Arizona, USA (4–8 minutes)[5,6] and Niigata, Japan (4 minutes 24 seconds).[7] In these countries, studies conducted in the days prior to the introduction of quality-conscious 30:2 CPR were able to demonstrate that there was no difference in outcome whether chest compression-only or the previous type of CPR, namely 15:2 or 5:1 CPR was carried out, with no emphasis on quality. It was also demonstrated that both the old forms of standard CPR and compression-only CPR were better than no bystander CPR at all. In all these communities, the pre-hospital emergency ambulance services arrived within a few minutes of call and took over CPR from the bystander owing to their short ambulance response time. Therefore, the duration of bystander CPR carried out in the majority of instances was just a few minutes.

In Singapore, a study on response time by emergency ambulance crew to cardiac arrest patients[8] revealed that the average time from the call for the ambulance to the arrival of the crew at the patient's side was 12.6 minutes. The time from cardiac arrest to crew arrival was 23.2 minutes. This meant that bystanders in Singapore would generally need to perform CPR for a prolonged period of an average of 15

minutes (much longer than in Japan or Arizona) before they would be relieved by ambulance crew. These differences are important to have a clear understanding of the approaches that need to be adopted to save more lives in countries such as Singapore, where the emergency response times are longer.

AHA GUIDELINES 2010

In October 2010, there were reports in the local and international media that the AHA did not recommend the use of mouth-to-mouth ventilation for laypersons performing CPR as it was apparently detrimental to survival rates. These reports were incorrect, as AHA has specifically mentioned that the steps taken by rescuers, whether lay rescuers (bystanders) or healthcare workers, when dealing with cardiac arrest patients would be determined by their level of training.

Specifically, the recommendations by AHA[9] were as follows:

- All trained lay rescuers should, at a minimum, provide chest compressions for victims of cardiac arrest. If the trained lay rescuer is able to perform rescue breaths, he/she should add breaths in a ratio of 30 compressions to two breaths. This bystander should continue to provide CPR until: (a) an automated external defibrillator (AED) arrives and prompts that chest compressions cease; (b) an ambulance crew arrives and takes over chest compressions; or (c) the patient wakes up.
- All CPR training programmes should include training in ventilation in addition to chest compression. However, if a bystander is not trained in CPR, then he/she should provide chest compressions only, with an emphasis on push hard and fast, and follow the directions given by the emergency medical dispatcher. The untrained bystander should continue compression-only CPR until one of the three situations described earlier occurs.

STUDIES ON COMPRESSION-ONLY CPR

Most of the initial studies on this technique used animals.[10] Animals in which cardiac arrest is initiated would, like humans, collapse. When CPR is performed on most animals, their more rigid oropharyngeal and glottic regions ensure a patent airway[11] that allows some passive ventilation during the relaxation phase of chest compressions. The human upper airway is relatively floppy and closes during human cardiac arrest unless active measures are undertaken to keep it open, such as the head-tilt chin-lift manoeuvre or insertion of an endotracheal tube. Therefore, more gas exchange is possible in animals than in the non-intubated human. Many laboratory-based animal studies done on compression-only CPR did not provide active chest ventilation. However, they sometimes allowed for an oxygen-enriched environment around the mouth of the collapsed animal with the use of a mask, through which oxygen was being actively driven so that these collapsed animals took in oxygen-enriched air during the phase of passive ventilation. Oxygen-enriched air is not available during bystander CPR in humans. These animal studies were able to demonstrate at least an equivalent effect of chest compression-only CPR and the previous standard of CPR, viz 15:2 CPR for short periods of chest compression (usually up to about five minutes) with no control on quality. These studies also demonstrated that either method of CPR was superior to no CPR at all.

On occurrence of cardiac arrest, brain damage begins after about 4–6 minutes if no CPR, including ventilation, is carried out, and the damage is usually severe by about ten minutes. It is also well known that survival generally decreases by about 7%–10% for every minute of delay in initiating resuscitative procedures. The ability of the human body to withstand lack of oxygen for more than a few minutes is questionable.

Animal studies have also demonstrated that during cardiac arrest without lung inflation and ventilation, there is a continuous decrease in blood oxygen saturation.[12,13] At some point (about six minutes of cardiac arrest), the haemodynamic advantage conferred by continuous chest compressions (without ventilations) is offset by the reduction in oxygen saturation. The ultimate result is a compromise in oxygen delivery. One porcine cardiac arrest study[13] (three minutes of untreated ventricular fibrillation [VF] followed by 12 minutes of CPR) showed that after four minutes of continuous chest compressions, delivery of two rescue breaths every 100 compressions provides a survival advantage over chest compressions alone. Animal studies mimicking bystander CPR with good-quality compressions for asphyxia-precipitated cardiac arrest[14] have also demonstrated that the addition of rescue breathing to compressions results in much better outcomes than chest compressions alone. Chest compression-only CPR was, however, superior to no CPR at all, even with asphyxia-precipitated cardiac arrest.

HUMAN STUDIES REPORTED IN 2007

Three randomised observational studies of human bystander CPR[15-17] were reported in 2007. None of these reported a negative impact on survival when ventilations were omitted for short intervals. All these studies were completed before the introduction of the current new CPR standard of 30

compressions to two ventilations in November 2005.

- The SOS Kanto study[15] conducted in Japan demonstrated that survival after bystander continuous chest compressions did not differ from survival after what was then standard CPR (15:2 or 5:1) for adult patients with witnessed out-of-hospital cardiac arrest.
- Iwami et al[16] reported no difference in one-year survival between victims of witnessed cardiac arrest who received bystander chest compressions only and those who received 15:2 or 5:1 CPR. However, among those who had bystander CPR for more than 15 minutes, the survival rate was greater in those who had received the above standard CPR of compressions and ventilations.
- Bohm et al[17] studied the one-month survival data from the Swedish registry of all victims of out-of-hospital cardiac arrest who received bystander CPR and found no statistically significant difference in outcomes between patients who had chest compressions alone and those who had 15:2 CPR.

All three of the above large studies could not assess or control the quality of bystander CPR delivered. All bystanders were, in those days, trained to the pre-2005 CPR guidelines, viz 15:2 or 5:1, with no emphasis on quality and little effort at minimising interruptions in chest compressions.

WHY HANDS-ONLY CPR?

Compression-only CPR has become very exciting and popular largely through the active intervention of the media, aided by a group of doctors from Arizona, who have made very active efforts[2-4] to promote what they believed was a workable form of CPR in an environment where the bystander CPR rate was very low. Much of this was initiated at a time when quality was not a factor in CPR practice.

There are some good reasons for the popularity of compression-only CPR:

- It may reduce the time to initiation of chest compressions and result in a greater number of chest compressions per minute with fewer interruptions, especially for the first few minutes after initiation of the resuscitation. Even trained rescuers performing traditional one-person CPR (15:2 or 5:1) take much longer to initiate CPR than those trained to perform compression-only CPR. This is due to the additional cognitive or emotional burden associated with attempting a more complex psychomotor task in traditional CPR[18-20] (which consisted of checking the oral cavity, giving two first breaths, checking for the pulse, no urgency for chest compressions and a lot of interruptions). In those days, there was little appreciation for the fact that interrupting chest compressions for more than a few seconds leads to adverse outcomes.
- Studies of basic life support providers trained before 2005 showed that both lay bystanders and healthcare workers who performed 15:2 or 5:1 CPR interrupted chest compressions to provide ventilations for much longer (16 ± 1 seconds and 10 ± 1 seconds, respectively) than the recommended intervals (6 and 3 seconds, respectively).
- In communities with short emergency ambulance response times (80% within 5–6 minutes), trained bystanders had to provide only about five minutes of chest compression-only CPR before a paramedic crew took over the resuscitation with 30:2 or 100:2 CPR with high-flow oxygen. Thus, there were no significant differences when outcomes were compared to the group performing the then-standard CPR. However, this equivalence was not demonstrated for those with long bystander CPR time (the Iwami study). In all these studies, the comparison was made with the 'poorer' old CPR standard.

The AHA released the advisory on bystander CPR[1] on March 31, 2008 for the following reasons:

- It was a desperate attempt to increase bystander CPR rates. In most American communities, except for a few such as King County, Seattle and Rochester, Minnesota, bystander CPR rates had hovered between 20%–30% and had not changed significantly over the years. It was hoped that chest compression-only CPR would appear simpler and thus lead to a significant increase in bystander CPR rates. On that basis, the proportion of survivors would naturally increase.
- It was believed that the mouth-to-mouth ventilation part of standard CPR resulted in fear of infection transmission, especially that of dreaded diseases such as HIV, hepatitis B and hepatitis C, even though these diseases were blood-borne infections and not transmitted through salivary or mucosal contact. Over the last 50 years of CPR, there has been no documented instance of HIV having been transmitted as a result of the procedure.[21]
- A number of studies involving healthcare workers[22,23] and ambulance crew[24] had indicated extreme reluctance on their part to perform mouth-to-mouth ventilation for victims of cardiac arrest. These workers would not perform mouth-to-mouth ventilation in their daily practices because they were used to employing

bag-valve-mask devices for ventilation. If similar attitudes were also extrapolated to members of the public, this would be a theoretical and potential barrier to the performance of bystander CPR.

Are the fears warranted? Should our practice of CPR in the community be guided by fears of causing harm, infection or legal reprisals? Or should it be guided by what constitutes best standard of care and focus on educational efforts at teaching laypersons the right skills in a simple and repetitive manner so that they are able to perform a reasonable standard of CPR for optimal benefit?

HAVE BYSTANDER CPR RATES INCREASED SINCE 2008?

There has been little evidence of this in most of the USA, except in Arizona, where a concerted and very active public education programme had been launched over the last six years, pushing maximally for the widespread teaching of compression-only CPR rather than 30:2 CPR. Almost no other state in the USA or elsewhere has witnessed such a concerted public education effort. No other form of CPR has been emphasised. After six years, it was noted that the bystander CPR rate had increased[25] from 28% to 40% and survival to hospital discharges had increased from 3.7% to 9.8%. During this same period, other improvements in the cardiac arrest management system were also implemented, such as shorter ambulance response times and improved post-resuscitation measures. Therefore, while the improvement in survival cannot be attributed solely to compression-only CPR, the increased bystander CPR rate was a result of the concerted and aggressive state-wide effort. Whether the same improvement in survival would have been seen if similar concerted efforts in standard good quality 30:2 CPR had been made by the same groups involved in extensive promotion of hands-only CPR would be conjecture. The same outcome has not been reproduced in any other states in the USA. In 2008, the bystander CPR rate[26] in the USA was an average of 33%. In 2011, the bystander CPR rate continues to be 33%. For most of the USA, the publicity surrounding the use of hands-only CPR did not result in an increase in bystander CPR rates.

WHAT HAS CHANGED OVER THE LAST FIVE YEARS (2005–2010)?

In Oslo, Norway, survival to hospital discharge increased from 10.3%–13.1% over a three-year period after the teaching of 30:2 CPR was implemented from 2005 to 2007.[27] In Minnesota, USA, widespread 30:2 CPR training in schools and workplaces, along with retraining of emergency medical services personnel enabled 12,000 people to obtain CPR training. They were able to demonstrate an improvement in survival to hospital discharge rates from 9.3% to 17% from 2005 to 2007.[28] Seattle, WA, USA, has the highest survival rate for out-of-hospital cardiac arrest for any city in the USA due to a concerted public CPR educational programme (in 30:2 CPR) supported by the state and a 44% bystander CPR rate.[26] Similar improvements have also been reported with the implementation of 30:2 CPR in Columbus, OH, USA (6.1%–9.4%)[29] and Copenhagen, Denmark (7.9%–16.3%).[30]

WHAT ARE SOME OF THE FEARS THAT INHIBIT PERFORMANCE OF CPR BY BYSTANDERS?

The move toward chest compression-only CPR was guided by the unwillingness to perform mouth-to-mouth ventilation expressed by a high proportion of healthcare workers and ambulance crew. When actual bystanders were interviewed, however, such reluctance was not expressed. Common reasons given by CPR-trained bystanders[31] for not performing CPR were the following: 37.5% stated that they panicked; 9.1% perceived that they would not be able to perform it correctly; and 1.1% thought that they would hurt the patient. Surprisingly, only 1.1% objected to performing mouth-to-mouth resuscitation. In out-of hospital cardiac arrest, it is unusual for first-responder CPR to be performed by a healthcare worker or an ambulance medic. Laypersons are the most likely performers of this skill. In a review of bystander CPR performed in Singapore[8] over a one-year period, only 27% performed compression-only CPR. The remaining 73% performed a mixture of both compressions and ventilations.

It is likely that the fears that prompted the move toward compression-only CPR in the USA may not truly reflect the feelings of the general public.[32] This would suggest that actions to improve bystander CPR rates in the country should be directed along the following lines:

- A very active and driven programme actively supported by the state to get as many members of the public to be trained and currently certified in CPR.
- For instructors to focus on motivating learners[33] and helping them to address fears and confidence issues in using the learnt skill of CPR.
- Ensuring an easily accessible refresher programme in CPR for skills retention.
- Focusing on teaching[34] of quality CPR as the approach to improving performance of bystander CPR in the event of out-of-hospital cardiac arrest in the community.

RESCUER FATIGUE DURING CPR

There is ample evidence to suggest that rescuer fatigue may lead to inadequate compression rate and depth.[35, 36] Such changes are usually evident after one minute of CPR, but rescuers may not recognise this.

An interesting study of volunteer travellers at Oslo airport compared CPR performance on manikins using 15:2, 30:2 and continuous compressions. Mean compression depth was 41 ± 11 mm, 45 ± 8 mm and 30 ± 8 mm, respectively. Depth was reduced as a function of time in the continuous compression group. Number of compressions per minute was 40 ± 9, 43 ± 14 and 73 ± 24 and the percentage of no-flow time was 49% ± 13%, 38% ± 20% and 1% ± 2%, respectively. The authors concluded that continuous chest compressions without ventilations gave significantly more chest compressions per minute, but with decreased compression quality (i.e. ineffective compressions). No-flow time for 30:2 CPR was significantly lesser than that for 15:2 CPR.[37]

That quality of chest compressions decays with continuation of chest compressions beyond one minute has been well described in a number of studies.[38-41] This would occur both in the out-of-hospital and in-hospital environments, even if the compressions were provided by well-trained ambulance crew. In another study of in-hospital performance of CPR with audiovisual feedback, chest compression depth decay became evident after 90 seconds.[35] Although compression rates did not change, the depths decreased significantly.

All these studies indicate that rescuer fatigue with poor compression depth is a real phenomenon, especially during performance of continuous chest compression CPR. While the rescuer may not be aware of the onset of fatigue and this may not reach critical proportions during the first few minutes, as would be expected in environments with short ambulance response times, the need to continue CPR for long periods in communities with long ambulance response times would mean that the patient would be receiving poor quality chest compressions for much of the time bystander chest compressions were being carried out. This would not be helping survival. The effects of rescuer fatigue appear to be significantly less with 30:2 CPR than with continuous chest compression (or hands-only) CPR.[36]

IS THERE A PLACE FOR CHEST-COMPRESSION ONLY CPR?

There is good evidence[42,43] to indicate that during dispatcher-assisted CPR, the use of chest compression-only CPR is equivalent to or slightly better than 30:2 CPR. This is to be expected as it is highly difficult for an ambulance dispatcher to teach an untrained lay rescuer the technique of mouth-to-mouth ventilation over the telephone and how to switch from chest compressions to ventilation. However, simply asking the caller to identify the centre of the chest and then push hard, and fast until the arrival of the ambulance crew would be much simpler. Chest compression is recommended for dispatcher-assisted CPR instructions given to previously untrained lay rescuers. This has already been introduced in Singapore. In spite of 30:2 CPR training given to laypersons, there would be a group of people who, for a variety of reasons, may either be unable to or unwilling to perform mouth-to-mouth ventilations. Rather than not offering CPR to the victim, the person should at least perform continuous chest compressions until the arrival of the AED or the ambulance crew.

CONCLUSION

In a community such as Singapore, where a large proportion of people live in high-rise apartments and where 70% of out-of-hospital cardiac arrests occur in the home environment, the response times for ambulance crew are expected to be considerably long, often over 15 minutes. Trained bystanders performing CPR on collapsed patients may need to continue the intervention for prolonged periods. Teaching them compression-only CPR would result in poor-quality chest compressions being performed for most of the time before the arrival of the ambulance crew. The non-provision of oxygen for prolonged periods would also mean that target organs would have been in a severe state of hypoxia for an extended period of time. All these factors spell the likelihood of poor outcomes for out-of-hospital cardiac arrest patients in the country. The way forward would be to teach the practice of good quality 30:2 CPR to as many laypersons as possible, with active support from all levels of the community so as to remove fears that inhibit CPR performance and create an army of confident and educated citizen life-savers.

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