

REVIEW

Reducing Barriers for Implementation of Immediate CPR with Chest Compressions Alone

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LIST OF ABBREVIATIONS:

AED = automatic external defibrillator
CCC = continuous chest compressions
CPR = cardiopulmonary resuscitation
CV = compression–ventilation
EMS = emergency medical services
ROSC = return of spontaneous circulation
VF = ventricular fibrillation

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ABSTRACT

It is well known that out-of-hospital sudden cardiac death is a leading public health problem. In the absence of early defibrillation, survival rates of patients with out-of-hospital cardiac arrest are dismal and have remained essentially unchanged. The guidelines advocate the same approach for 2 entirely different pathophysiological conditions: respiratory arrest in which severe arterial hypoxia and hypotension eventually lead to secondary cardiac arrest, and primary cardiac arrest in which the arterial blood is fully saturated with oxygen at the time of the arrest.

Cardiopulmonary resuscitation (CPR) is traditionally defined as chest compressions plus ventilations. The need for chest compressions is unquestionable, while the need for mouth-to-mouth ventilations for cardiac arrest has been questioned. Recent observational studies underline the paramount role of chest compressions in an alternative way of CPR, compression only CPR. Public education and training in compression only CPR is much simpler. *Compression only CPR* may significantly increase bystander-initiated resuscitation efforts and thereby give patients a better chance of survival, given the reluctance of lay people to provide mouth to mouth rescue breaths.

In view of the above, the principal question is, what barriers are delaying the guidelines from recommending compression only CPR? Perhaps the major problem is the difficulty to change the paradigm. For decades, the “ABCs” (airway, breathing, and circulation) have been advocated for bystander basic life support, making it extremely difficult to transform the so ingrained in the popular understanding “ABC” to “AC”.

INTRODUCTION

The most important cause of death in the adult population of the industrialized world is sudden cardiac arrest due to coronary artery disease. The first recorded rhythm in patients presenting with a sudden cardiovascular collapse is ventricular fibrillation (VF) even if its percentage is declining according to recent studies, whereas bradyarrhythmias are thought to be responsible for a minority of sudden cardiac arrests.

COMPRESSION-ONLY CPR

The actions linking the victim of sudden cardiac arrest with survival are called the *chain of survival*.¹ These actions include four separate steps, early recognition of the emergency and activation of the emergency medical services (EMS), early cardiopulmonary resuscitation (CPR), early defibrillation and early advanced life support.

CPR plays a fundamental role in the chain of survival acting as a link between the recognition of cardiac arrest and defibrillation that in fact restores life. In a way CPR buys time while waiting for the defibrillator to arrive. When there is no delay in the initiation of bystander CPR, the successful outcome can be doubled or tripled.

CURRENT RESUSCITATION GUIDELINES

In the European Resuscitation Council Guidelines for Resuscitation published in 2005,¹ emphasis was given in the quality of CPR. Chest compressions play a crucial role in the resuscitation attempt. They produce blood flow by increasing the intrathoracic pressure and by directly compressing the heart. A small but critical amount of blood flow to the brain and myocardium is generated, thus increasing the likelihood that defibrillation will be successful. Chest compression is especially important if a shock cannot be delivered sooner than 4 or 5 min after collapse. A major determinant of survival after cardiac arrest is coronary perfusion pressure, i.e., the difference between the aortic and right atrial pressures during the release phase of chest compression. The basic element in establishing stable coronary perfusion pressure is the limitation in chest compression interruptions. As there are several cycles of chest compressions needed to establish a constant coronary perfusion pressure, frequent interruptions have a deteriorating effect on survival rate by diminishing the already poor cardiac output.

Noticing that there were many interruptions to chest compressions, resuscitation algorithms have been updated in 2005.

1. The initiation of resuscitation efforts should rely on the absence of normal breathing rather than carotid pulse, checking for movement, breathing or coughing ('signs of a circulation'). This less time-consuming approach seems diagnostically superior in the identification of cardiac arrest, considering that agonal gasps are not misinterpreted as normal breathing. Agonal gasps are frequently present in cardiac arrest victims and described as barely breathing, heavy or laboured breathing, noisy or gasping breathing.
2. The blood oxygen content remains high during the first few minutes after non-asphyxial cardiac arrest. Thus, myocardial and cerebral oxygen delivery is limited more so by the diminished cardiac output, rather than a lack of oxygen. Ventilation is, therefore, initially less important than chest compressions. And for these reasons it is recommended that in adults, CPR should start with chest compression, rather than initial rescue breaths.
3. Hyperventilation (many breaths or large volumes) increases intrathoracic pressure, decreases venous return to the heart and thus diminishes cardiac output.² There is also a small amount of air that passively exchanges through chest compressions. Therefore giving each rescue breath over about 1 sec than 2 sec is currently recommended. In addition rescuers are not recommended to attempt up to five rescue breaths in order to apply two effective breaths.
4. Complicated ways of finding the proper site for chest compressions have been abandoned. Placing rescuer's hands in the middle of the victim's chest is a simple, easy to remember and be taught, method that spares time for chest compressions.
5. A single compression – ventilation (CV) ratio of 30:2 than 15:2 is recommended for adult CPR.^{3,4} This single ratio simplifies teaching, promotes skill retention but the most important is the increase in the number of compressions in a given time and the subsequent decrease in compressions interruption.
6. When a shockable rhythm is confirmed by the defibrillator, a single shock should be delivered followed by immediate resumption of chest compressions and ventilations in a ratio of 30:2 for 2 minutes, irrespective of the underlying rhythm. The single shock strategy is guided by the high success rate in converting a shockable rhythm with the first shock, which is essentially decreased with the second or subsequent shocks. The immediate resumption of CPR without delay for rhythm analysis minimizes the 'no-flow' time and enhances the probability of success for the next shock or the return of spontaneous circulation (ROSC) given the fact that even if the rhythm is restored it is hemodynamically inadequate.

Counting on the fact that when stopping chest compressions, the coronary flow decreases substantially, while on resuming chest compressions, several compressions are necessary before the coronary flow recovers to its previous level, the above described changes in the Guidelines for Resuscitation published in 2005 emphasize the role of chest compressions. But is this enough?

COMPRESSION-ONLY CPR

Taking into account the reluctance of either lay people or health care professionals in providing mouth-to-mouth ventilation, the International Liaison Committee on Resuscitation (ILCOR) formed in 1993 encourages for the first time lay people, who are unable or unwilling to provide rescue breaths, to perform compression-only CPR.

One of the many important concepts that have been published is the 3-phase time-dependent concept of cardiac arrest due to VF articulated by Weisfelt and Becker.⁵ The *first phase* is the electrical phase, which lasts approximately 5 minutes. During this phase, the most important intervention is prompt defibrillation. This is why the benefit of the automatic

external defibrillator (AED) has been shown in a wide variety of settings, airports, casinos, and in the community. The *second phase* of cardiac arrest due to VF is the hemodynamic phase; this phase lasts for a variable period of time, but possibly from minute 5 to minute 15 of the arrest. During this time, generation of adequate cerebral and coronary perfusion pressure is critical to neurologically normal survival. The *third phase* is the metabolic phase, for which innovative new concepts are needed, the most promising of which is the application of hypothermia.

Valenzuela et al retrospectively reviewed 61 adult out-of-hospital cardiac arrest patients treated by the AED-equipped Tucson Fire Department.⁶ They noted an additional mean time of 54 seconds to the median time from "911" call receipt to arrival at the patient's side until the first defibrillation attempt. Chest compressions were performed only 43% of the time during the resuscitation effort (data derived from AED recordings). Frequent interruptions of chest compressions result in no circulatory support during more than half of resuscitation efforts; interruptions could thus be a major contributing factor to the continued poor outcome seen with out-of-hospital cardiac arrest.

Cobb and associates improved survival by performing chest compressions for 90 seconds before applying the AED.⁷ Wik et al, from Oslo, Norway,⁸ who performed either 3-minute chest compression before defibrillation or defibrillated first, found that when the ambulance arrived in less than 5 minutes (during the electrical phase of cardiac arrest), there was no difference in outcome; however, when the ambulance arrived after 5 minutes (during the hemodynamic phase of cardiac arrest), there was a dramatic difference. Given that the average arrival time of paramedic/fire-fighters is approximately 7 minutes, in the hemodynamic phase of cardiac arrest, chest compressions play a crucial role in the victim's outcome.

The improved outcome when chest compressions were applied before defibrillation in a given period after cardiac arrest prompted the question if chest compressions without any ventilation can also offer a favourable outcome. Taku Iwami and his associates carried out a prospective, population-based, observational study which enrolled all persons ≥ 18 years of age who suffered out-of-hospital cardiac arrest of presumed cardiac origin, were witnessed by bystanders, and were treated by EMS in Osaka Prefecture from May 1, 1998, through April 30, 2003.⁹ Crude 1-year survival with favourable neurological outcome after witnessed cardiac arrests of presumed cardiac origin was more frequent in the cardiac-only resuscitation group (3.5%) and the conventional CPR group (3.6%) than the no bystander CPR group (2.1%). The outcomes of witnessed VF cardiac arrests were similarly improved with both cardiac-only resuscitation and conventional CPR.

Bohm and co-workers from the Stockholm Prehospital Centre, Karolinska Institute, compared the 1-month survival rates among patients after out-of-hospital cardiac arrest who

had been given bystander CPR in relation to whether they had received standard CPR with chest compression plus mouth-to-mouth ventilation or chest compression alone.¹⁰ Among 11 275 patients who were reported to the Swedish Cardiac Arrest Register between 1990 and 2005, there was no significant difference in 1-month survival between patients who received standard CPR (1-month survival=7.2%) and those who received chest compression only (1-month survival=6.7%). It is worth mentioning that there was an additional 17% of patients who received mouth-to-mouth CPR only (and were excluded from the primary analysis) indicating the false impression for untrained lay people regarding the vital role of ventilation.

The SOS-KANTO observational study investigated the efficacy of bystander resuscitation by chest compressions without mouth-to-mouth ventilation (cardiac-only resuscitation).¹¹ The primary endpoint was favourable neurological outcome 30 days after cardiac arrest. The analysis showed that cardiac-only resuscitation by bystanders is the preferable approach to resuscitation for adult patients with witnessed out-of-hospital cardiac arrest, especially in the subgroup of patients with apnea, shockable rhythm, or short periods of untreated arrest.

Taku Iwami's study in contrast to SOS-KANTO showed no difference in outcomes between cardiac-only resuscitation and conventional CPR group for witnessed VF.⁹ Although both studies were carried out in Japan and backgrounds like race of the participants and the EMS systems were quite similar, the Utstein Osaka Project is population based and the SOS-KANTO is hospital based, suggesting some inherent differences between the two studies. For example, 40% of cardiac arrests in the SOS-KANTO study occurred at public locations in contrast with only 18% in the Utstein Osaka study. This might affect the results because it is well established that outcomes from out-of-hospital arrests are better in public locations.

The Guidelines for Resuscitation published in 2005 changed the recommendations for single-rescuer CPR from 2:15 ventilations-to-chest compressions (2:15 CPR) to 30:2 chest compressions-to-ventilations (30:2 CPR).¹ The rationale for these changes was to provide more chest compressions per minute. Iwami and associates from Osaka, Japan, Bohm and colleagues from Sweden and the SOS-KANTO observational study, compared the survival rates of patients with cardiac arrest in those who received bystander chest compressions alone and those who received traditional CPR (2:15 CPR).⁹⁻¹¹

Gordon Ewy and his associates compared the 24-hour neurologically normal survival between continuous chest compressions (CCC) without assisted ventilations with 30:2 CPR in a swine model.¹² The purpose of the study was to determine whether the 2005 guideline-recommended single-bystander 30:2 CPR results in equivalent or different 24-hour post-resuscitation normal neurological function compared with CCC. The number of neurologically normal survivors 24 hours after resuscitation was significantly greater in the CCC

groups (23 of 33, 70%) compared with the 30:2 CPR groups (13 of 31, 42%; $P=0.025$).

Several mechanisms might account for the efficacy of cardiac-only resuscitation.¹³⁻¹⁷ Gasping breathing and passive chest recoil during chest compressions provide some air exchange. Measured minute ventilation and arterial oxygenation decrease after 4–10 min of resuscitation irrespective of ventilation. Several studies suggest that ventilation is not essential during the initial 12 min of resuscitation with untreated arrest intervals of less than 6 min and that gasping breathing is associated with a better outcome. Another reason for the efficacy of cardiac-only resuscitation is the potential disadvantages of mouth-to-mouth ventilation. These disadvantages include gastric insufflations and importantly, less time for chest compressions that support cerebral and coronary perfusion. Intrathoracic pressure drops after each pause for mouth-to-mouth ventilation, and several chest compressions have to be done before previous rates of cerebral and coronary perfusion are re-established.

On the other hand, the predominant mechanism of cardiac arrest in victims of trauma, drug overdose, drowning, and in many children is asphyxia, so rescue breaths are critical for resuscitation of these victims. Also rescue breathing may be of some help for very prolonged cardiac arrests (> 15 minutes from collapse to EMS resuscitation). Survival with favourable neurological outcomes in these patients, even when conventional CPR is provided, is disproportionately small, and therefore the absolute number of patients who may benefit from conventional CPR is quite small.

CONCLUSION

A substantial barrier to any CPR attempt is the reluctance of bystanders to undertake mouth-to-mouth ventilation. This reluctance is partly caused by fear of transmission of infectious diseases. Despite the remote chance of such infection, fears about disease transmission are common in the present era of universal precautions. Another barrier to bystanders attempting CPR is the complexity of the technique as presently taught. Both these reasons contribute to the attitude of the vast majority of lay people who avoid any rescue effort; making an attractive alternative the motto “when you don’t know what to do, do compressions”.

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