Modified cardiopulmonary resuscitation (CPR) instruction protocols for emergency medical dispatchers: rationale and recommendations

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Received 27 July 2004; received in revised form 1 November 2004; accepted 1 November 2004

Abstract

Background: International consensus guidelines now support the use of “chest compressions-only” cardiopulmonary resuscitation (CPR) instructions (CCCOIs) by emergency medical dispatch (EMD) personnel providing telephone assistance to untrained bystanders at a cardiac arrest scene. These guidelines are based largely on evolving experimental data and a clinical trial conducted in one venue with distinct emergency medical services (EMS) system features. Accordingly, the Council of Standards for the National Academies of Emergency Dispatch was asked to adapt a modified telephone CPR protocol, and specifically one that could be applied more broadly to the spectrum of EMS systems.

Methods: A group of international EMD specialists, researchers and professional association representatives analyzed available scientific data and considered variations in EMS systems, particularly those in Europe and North America.

Results and conclusions: Several recommendations were established: (1) to avoid confusion, bystanders already providing CPR should continue those previously learned methods; (2) following a sudden collapse unlikely to be of respiratory etiology, CCCOIs should be provided when the bystander is not CPR-trained, declining to perform mouth-to-mouth ventilation or unsure of actions to take; (3) following 4 min of CCCOIs, ventilations can be provided, but, for now, only at a compression-ventilation ratio of 100:2 until EMS arrives; (4) until more data become available, dispatchers should follow existing compression-ventilation protocols for children and adult cases involving probable respiratory/trauma etiologies; (5) EMD CPR protocols should account for EMS system features and receive quality oversight and expert medical direction.

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Keywords: Cardiopulmonary resuscitation; CPR; Sudden cardiac death; Out-of hospital-CPR; Bystander CPR; Cardiac arrest; 9-1-1 Systems; Emergency medical dispatcher; Emergency medical services; EMS; Ventilation; Mouth-to-mouth resuscitation; Pre-arrival instruction; Dispatch life support

1. Introduction

Persons experiencing out-of-hospital cardiac arrest who receive immediate basic cardiopulmonary resuscitation (CPR) from witnessing bystanders clearly have better chances of surviving the event with good neurological recovery [1]. One strategy to improve the frequency and earlier performance of bystander-performed CPR has been to train emergency medical dispatch (EMD) personnel receiving...
calls at public safety answering points (e.g., 9-1-1 telephone centers in the United States) to provide protocol-based CPR directives over the telephone while awaiting the arrival of emergency responders [1–8].

Considering the non-visual and emotional nature of telephone interrogation and instruction in critical emergencies, “dispatch life support” (DLS) has evolved as a specialized methodology [9,10]. The routine provision of medical instructions prior to arrival of responding emergency medical services (EMS) crews is recognized as an essential link in the “chain of survival” and an international standard of care [11–15]. Such “pre-arrival instructions” have increased the frequency of bystander CPR and are even expected by the lay public as a standard of care [4]. Dispatcher-assisted CPR (D-CPR) instructions are believed to improve survival chances by increasing the number of persons receiving CPR and facilitating earlier intervention [5].

Since the 1980s, D-CPR instructions have included the traditional “A-B-C” techniques taught in CPR classes, namely airway maintenance, rescue breathing, and chest compressions. However, expeditious compliance with these multiple directives can be extremely difficult, especially when (undemonstrated) instructions are provided, for the first time, over the telephone, to a frightened person in a stressful situation [16]. Among various techniques to improve caller compliance, research indicates that an individual functions better with a shorter number of sequential steps [9,16–18].

Although traditional “A-B-C” CPR saves lives, the relative contributions of the “breathing” component are not well-delineated. Investigators are now examining certain problems with ventilation during CPR. While some concern exists that would-be rescuers do not perform CPR because they have fear of communicable diseases, most importantly, there are also physiological concerns [19–21]. For example, frequent interruption of chest compressions to provide rescue breaths counteracts maintenance of coronary perfusion pressure, the key determinant of resuscitation [22–23]. Some unassisted ventilation (e.g., without rescue breathing) can occur during CPR, including air movement during chest compressions and, in many cases, agonal spontaneous respirations, an activity which usually occurs in those most likely to survive [24,25]. In certain animal models, these sources of ventilation can be quite adequate for several minutes [25–28].

Recognizing these issues, in the late 1990s, the American Heart Association (AHA) called for a re-appraisal of rescue breathing and formal studies of traditional procedures [29]. Concomitantly, a clinical trial from the Seattle 9-1-1 office demonstrated an impressive trend toward improved survival (14.7% versus 10.4%) when chest compressions-only instructions (CCOIs) from dispatchers were compared to standard A-B-C instructions [3].

Subsequently, the AHA modified their recommendations for D-CPR to give CCOIs in the following circumstances:

1. “When a rescuer is unwilling or unable to perform mouth-to-mouth rescue breathing” and

2. “For use in dispatcher-assisted CPR instructions where the simplicity of this modified technique allows untrained bystanders to rapidly intervene” [11].

Based on available evidence, these recommendations are very reasonable. However, they were still based on experimental data and the unique aspects of the EMS system involved in the one clinical trial. In other words, Seattle has a high frequency of bystander CPR training and performance, possibly involving an effect from secondary bystanders, and the mean response interval for EMS first responders is about 4 min (measuring time of dispatch until arrival at the street address) [3]. In systems with fewer CPR trainees or lengthier responses, rescue breathing may be more delayed, diminishing the relative effectiveness and tolerance of CCOIs.

Recognizing these caveats, a working group for the Council of Standards of the National Academies of Emergency Dispatch was asked to develop a D-CPR protocol that could be made applicable more broadly using the available scientific data and involving a consensus from international EMG specialists, including professional society representatives. The resulting recommendations are listed in Table 1 and the following discussion reviews the rationale for these modified PAIs and the evidence supporting CCOIs.

2. Rationale for “chest compressions-only” CPR approaches

2.1. Diminished ventilatory demands during CPR situations

Nearly 90% of all sudden natural deaths in Western Societies have a cardiac etiology, and 80% of these are attributable to coronary artery disease [30], most often presenting as sudden ventricular fibrillation (VF) [1]. While some out-of-hospital CPR cases result from hypoxic etiologies such as drowning, choking, or respiratory failure, these cases constitute a relatively small percentage of those faced by dispatchers. They are also very likely to be identified circumstantially (e.g., a submerged young person, a chronic lung patient with worsening dyspnea for several hours or a lunging person turning cyanotic and grasping their throat before their collapse) [11].

VF is a highly reversible process when a defibrillator is immediately available [1] or when a bystander performs CPR immediately in a rapid-response EMS system [1]. The remaining cardiac arrest patients presenting with asystole or “pulseless electrical activity” can also be resuscitated from occasionally, but much less frequently, even with early implementation of basic CPR by bystanders [1,31].

Although most primary cardiac processes rapidly lead to global ischemia, they are usually not caused by it. For example, at the onset of VF, the blood and most body tissues, including much of the heart itself, are well-oxygenated. The primary disorder is sudden absence of circulation secondary
Table 1
Recommendations from the Council of Standards of the National Academies of Emergency Dispatch (NAED) regarding dispatcher-assisted cardiopulmonary resuscitation (CPR) instructions provided by emergency medical dispatch (EMD) personnel to bystanders at the scene of a presumed cardiac arrest:

(1) Bystanders conveying that they or others on-scene are CPR-trained rescuers and therefore not requesting CPR instruction assistance, should provide the techniques that they were trained to perform

To avoid confusion for those bystanders who are actively providing CPR (and not requesting detailed assistance), EMD personnel should reinforce the standards that these bystanders were previously taught (e.g., the current 15:2 compression–ventilation ratio or whatever new training guidelines they may have received)

While the Council recommends that trained bystanders perform the techniques they were taught, it also strongly recommends further research into current practices, both for children and adults [55,59], given that the preponderance of evidence supports infrequent interruption of chest compressions and suggests that a much slower ventilatory rate may be advantageous in pulselessness and severe shock states, even after several minutes of those shock states. Also, if bystander states that they have been previously trained in CPR, but they are still requesting D-CPR instructions because they cannot remember what to do, recommendations 2 or 3 (see below) may be applied.

(2) EMD personnel should provide chest compressions-only CPR instructions in the immediate few minutes after a sudden collapse

When providing protocol-driven dispatch CPR instructions (D-CPR) to untrained rescuers in adult cases of sudden cardiac death (presumably secondary to ventricular fibrillation in most cases), there should be omission of mouth-to-mouth ventilation instructions, particularly for the first few minutes following the presumed onset of the sudden arrest. Such chest compressions-only instructions also should be given to individuals declining to perform MTMV or those unsure of techniques to perform

(3) Lung inflations should be provided eventually, but infrequently

Protocol-driven MTMV instructions should be eventually provided to the untrained rescuer after approximately 4 min of CCOIs (or about 400 chest compressions). Also, considering the fatigability of the rescuer in performing 400 consecutive chest compressions, the Council recommends that the on-scene rescuer should then provide such MTMV breaths after each subsequent cycle of 100 chest compressions (a relatively easy number to count) [57,58]. Specifically, after the first 400 chest compressions, two rescue breaths should be given and, subsequently, this same 100:2 ventilation to compression ratio should be continued until the arrival of EMS responders

While the Council recognizes the relatively arbitrary nature of these conclusions, based on the best available information and reasonable inferences from physiological and experimental data, they provide a relatively logical guide for EMD personnel working in a variety of settings worldwide. While ratios such as 50:2 may be more optimal in certain models [55], a pause every minute may be easier to implement, and it will diminish interruptions of compressions for the novice rescuer who may need longer pauses for ventilation. In some respects, the introduction of some breathing after several minutes of cardiac arrest, even at a 100:2 ratio, may be considered a more “conservative” approach than the current recommendations for dispatchers which advise chest compressions-only instructions (for the untrained rescuer) until professional rescuers arrive. Although the American Heart Association and other international consensus groups have not yet changed worldwide standards for compression–ventilation ratios, the preponderance of data appears to support the evolving notion that current ventilatory rates are still too frequent, even in the absence of gasping and prolonged periods of arrest

(4) EMD personnel should provide current rescue breathing—CPR instructions for child and adult cases involving probable respiratory and trauma etiologies

Current rescue breathing (i.e., MTMV) instructions should not be deleted when providing protocol-driven D-CPR instructions to rescuers when the following situations can be readily identified: pediatric patients, toxic overdose, hanging or strangulation, drowning, carbon monoxide poisoning, smoke inhalation, allergic reactions, severe trauma, and lightning strikes

While use of CCOIs has been supported in a clinical trial involving adults with sudden cardiac arrest, there still remains a concern that certain populations of cardiac arrest patients would benefit more from earlier MTMV. Such patients are those most likely to have presumed pre-arrest hypoxemia and to be already hypo-perfused and presumably less likely to be gasping adequately at the time of cardiac arrest [54]. In addition, this special consideration might be given to individuals discovered following an unawitnessed event, with presumed prolonged arrest intervals

(5) D-CPR protocols should account for EMS system features and receive quality oversight and expert medical direction

Medical direction and quality assurance are key components of EMD and should be an intrinsic aspect of D-CPR protocol implementation and ongoing quality oversight. D-CPR instructions should account for system features (e.g., range of response intervals and first-responder capability and training) and EMD protocols should be coordinated with response agencies’ medical directors. In turn, applicable responder and public education should be provided, most preferably before EMD protocol implementation

While the purpose of the NAED is to create a uniform national standard, it does so by examining and responding to concerns and variations in various local EMS systems. Ongoing local quality assurance and feedback to NAED is seen as an integral and expected aspect of the EMD function

to an electrical arrhythmia, not respiratory insufficiency. With the limited circulation provided by chest compression, reasonable arterial oxygen saturation may persist for several minutes following VF onset [32]. In other words, there is less impetus to provide immediate respirations for oxygenation.

Likewise, there is also little need to attempt to rapidly remove CO2 from the body during periods of pulselessness, regardless of etiology [33]. During manual chest compressions, cardiac output and pulmonary blood flow may be less than 15% of normal, even when started immediately, resulting in pronounced reduction in tissue oxygen delivery [34]. In such severe shock states, a significant reduction in total body CO2 production ensues and the pursuant need to eliminate it [33,35]. Even though metabolism of residual tissue O2 may continue (or even accelerate) in certain organs during the immediate first few minutes following sudden circulatory arrest (such as the heart and brain), this activity is transient and eventually dissipates. While this transient persistence of oxygen consumption can lead to a concomitant surplus of CO2 in those tissues, blood flow back to the lungs (to remove that CO2) still is severely compromised despite optimal performance of chest compressions [33,35]. This makes elimination
of the CO₂ difficult regardless of respiratory interventions. While one can increase end-tidal CO₂ production somewhat with more effective and persistent chest compressions (due to increased blood flow) [36], until pulses are returned, substantially less ventilation is necessary in most cases using current methodologies [33].

2.2. Eventual need for lung inflation and sources of respiration during CPR

While ventilatory demands to remove CO₂ generally will remain low throughout CPR conditions, blood O₂ saturation still requires maintenance of the inflation (or re-inflation) of certain dependent lung zones subject to alveolar closure [37,38]. Especially in the face of a cardiac arrest with vigorous chest compressions, lung deflation, and thus red cell desaturation, eventually becomes an important issue. While supplemental oxygen may provide some value, the extent and number of deflated lung units is the major concern in terms of oxygenation [37]. The key issue is to determine the point at which assisted lung inflation (i.e., alveolar recruitment) may eventually be required.

As mentioned previously, although assisted breathing with mouth-to-mouth ventilation (MTMV) has been emphasized as a critical component of traditional bystander CPR training, there are other potential sources of oxygenation and ventilation during cardiac arrest and the performance of CPR. For example, during CPR, air is expelled from the thorax during the compression phase and then, to some degree, passively inhaled during the elastic recoil of the chest wall (assuming an open airway) [25]. Also, because the brainstem and respiratory apparatus usually remain oxygenated up until the time of a sudden cessation of circulation, spontaneous respirations, in the form of agonal or gasping breaths, commonly continue to occur in both animals and humans in the early phases of sudden cardiac arrest [26,29,38]. Observation of spontaneous gasping is associated with a better outcome, possibly reflecting lesser/shorter ischemic insult to the brain, a likely conclusion considering that they are most often observed in witnessed collapses [24,38-40]. Also, gasping may be preserved for longer periods of time with early and effective CPR, probably reflecting more preserved oxygenation of the brainstem and respiratory apparatus [24,29,38]. While these spontaneous ventilations eventually deteriorate due to the less than optimal perfusion of the brain and respiratory muscles during CPR, it is believed that they may still provide relatively effective respirations during the first few minutes after a sudden cardiac arrest [38,39].

Ironically, the special mechanics of gasping may actually improve the effectiveness of CPR because they can potentially generate a larger and more powerful respiratory effort than a normal resting breath, at least early on [38]. Therefore, initially, these kinds of breaths can result in larger, more efficient, lung inflations, better ensuring dependent lung zone inflation and more CO₂ clearance than most normal breaths [29,37,38]. In addition, these inspiratory efforts can often generate enhanced negative intrathoracic pressures, thus significantly enhancing venous return to the heart [29,38]. As a result, teleologically occasional gasping may be the best ventilatory response during the first few minutes following cessation of circulation [38].

2.3. Animal models of ventilatory demand during CPR conditions

Several experimental models have demonstrated explicitly that animals can maintain adequate ventilation (removal of CO₂) as long as 12 min with chest compressions-only following VF-induced arrest [25-28,32]. This observation reinforces the notion that gasping breaths and chest compressions can maintain an adequate degree of ventilation during cardiac arrest. Likewise, animal models also demonstrate that adequate oxygenation (red cell saturation) can be maintained, at least for several minutes with “chest compressions-only” after sudden cardiac arrest [25]. However, beyond several minutes of cardiac arrest (more than 4 or 5 min) or with pharmacological paralysis (blocked gasping), some form of ventilatory support becomes increasingly necessary to maintain lung inflation and red cell saturation [25,29]. It should be noted that animals may also gasp more than humans; perhaps, in part, because they receive more optimal compressions in the laboratory setting [29,38].

In asphyxial arrest, assisted ventilation is theoretically more of a priority because the arrest is presumed secondary to significant and progressive interval of tissue hypoxia [41]. Likewise, there is concern that certain patients may not be able to gasp or have the ability to overcome an occluded (relaxed) airway. Nevertheless, one animal study compared 6 min of standard CPR (including assisted ventilation with a patent airway) to chest compressions-only CPR with a totally occluded airway. This study found no difference in 24 h survival between the two groups [23]. While arterial blood gases were not as good with the occluded airway, hemodynamic variables remained significantly better with compressions-only, suggesting that, despite poorer saturation, overall oxygen delivery to the tissues may be matched by the improved flows [23]. While this study was not a true model of hypoxic etiology because VF was induced initially and then the tracheal tube was clamped, it did demonstrate that chest compressions-only CPR can be effective for the first few minutes, even if there was no ventilation in an arrest of cardiac origin.

To assimilate the essence of these data, animals with sudden arrests (i.e., VF-induced versus those of respiratory origin) may tolerate several minutes (4–5 min) of “chest compressions-only” CPR in terms of their respiratory status, particularly with the presence of gasping respirations. Eventually, some degree of support needs to begin to maintain adequate oxygenation (lung inflation). Meanwhile, adequate ventilation (removal of CO₂) appears to be maintained for even longer periods of time without assisted breaths. One might then conclude that, in cases of sudden cessation of cir-
culation, “chest compressions-only CPR” may be adequate for several minutes. Although rescue breaths may then be needed to generate an adequate lung inflation for red cell saturation, the frequency of those breaths should still remain low.

Recent animal studies support this conclusion. In another porcine model of four different chest compression–ventilation ratios, a group receiving compressions-only for 4 min followed by the compression–ventilation ratio of 100:2 (for more than 10 min) achieved better neurological outcomes than those receiving more frequent breaths (15:2 ratio) [42]. Both of these groups had better outcomes than those receiving no assisted breaths at all [42].

2.4. Clinical studies of ventilation during bystander CPR

Despite the growing evidence in animals to the contrary, several observational studies in humans still support the overall superiority of bystander CPR using combined ventilation and chest compressions over “incomplete CPR” (defined as either compressions alone or ventilatory assistance alone) in terms of outcome [43–45]. However, in many of the cases, CPR by bystanders did not start until after the first few minutes (early dispatch phase) following the arrest. Also, among these studies, it was also shown that cases involving “full” or “correct” CPR may have been those situations in which CPR was performed by a trained healthcare provider who, in turn, was more likely to be evaluated as having performed “correct” or better quality CPR [43–45]. In addition, when specifically stratified to examine chest compressions alone, the differences for “incomplete” CPR were not as marked in terms of outcome [43–45]. In fact, in one study examining quality and outcome of bystander CPR, if chest compressions alone were performed, the reported quality of the CPR was generally very good in nearly half of the cases outcome [43]. More importantly, the outcome of such cases (those reported to have “high quality” chest compressions performed without mouth-to-mouth ventilation) may even be relatively better in terms of long term survival than those cases involving combined ventilations and compressions (15% versus 12%, respectively) [43].

2.5. Potential problems with mouth-to-mouth ventilation

One might still recommend that rescue breaths be given immediately just to avoid any doubt about ensuring proper ventilatory support for those not gasping or those whose arrest may have had an unrecognized hypoxic origin. Nevertheless, some researchers believe that, for several reasons, rescue breathing with mouth-to-mouth ventilation can actually be detrimental. First of all, the expired gas delivered by a rescuer during MTMV contains much higher levels of CO2 and reciprocally lower levels of oxygen than ambient air [29,46]. Therefore, MTMV breaths are slightly more hypoxic and hypercarbic than gasping breaths and chest compression-induced ventilation [47]. Also, when no tracheal tube is in place, assisted ventilation may not only lead to inadequate alveolar ventilation, but also to increased gastric insufflation and the secondary risk of aspiration of gastric contents. It has been reported that aspiration occurs in at least 29% of patients who cannot be resuscitated and almost half of all patients with unsuccessful CPR have air-filled stomachs [48]. Another problem is that MTMV is also more difficult to perform than chest compressions alone and that it may be aesthetically unpleasant for many would-be rescuers [29,49]. Bystanders at cardiac arrest scenes are less likely to perform CPR on a stranger if MTMV is required and, conversely, more likely to perform it if they feel free to do compressions only [19,20,29].

2.6. Interference with coronary blood flow during CPR

The most compelling concern regarding MTMV is that it delays or interferes with the delivery of chest compressions [21,29,36]. This particular concern is even more exaggerated when D-CPR instructions are given over the phone to an individual without prior CPR training. Dispatchers attempting to give traditional CPR instructions over the phone spend significant amounts of time addressing the movement of the patient onto the floor and then positioning the head and neck, pinching the nose and delivering the initial breaths. In contrast, COCIs have been shown to be completed more often and chest compressions begun 1.4 min earlier than when instructions for standard CPR are provided [3].

Most importantly, once chest compressions are begun, they are continually interrupted to provide intermittent MTMV. In turn, studies have shown that recommended rates of compressions (e.g., 100 per minute) are rarely achieved [36]. More concerning is the fact that coronary perfusion pressures fall off significantly as breaths are given and that it may take many compressions to restore the same pressure achieved just prior to giving the intermittent rescue breaths [21,22]. In other words, the more often compressions are interrupted (i.e., 5:1 versus 15:2 compression–ventilation ratios), the less apt one is able to achieve and sustain reasonable coronary perfusion [21]. As a result, cumulative coronary perfusion pressures (measured over a given minute) are markedly reduced when interrupted for rescue breaths. Considering that restoration of adequate coronary perfusion is the single most important determinant of successful resuscitation [29], there is significant concern about the frequent interruption of chest compressions to perform what may be a relatively unnecessary action in the immediate minutes following sudden cardiac arrest. While recognizing the more optimal conditions of the animal laboratory, left ventricular myocardial blood flows in swine receiving chest compressions-only have the potential to be nearly as high as the pre-arrest baseline [21].

Therefore, assimilating all of the available information, one could argue that with earlier, uninterrupted chest compressions, coronary perfusion pressures remain in a better range, and, in turn, perfusion of the brain and respiratory apparatus are better sustained, thus prolonging gasping respirations. Because gasping is believed to provide better gas...
exchange and enhanced venous return [24,37,38], its prolongation may, in turn, also delay cardiovascular deterioration such as that occurring when the peripheral vasculature begins to lose tone from under-perfusion [50]. When vascular tone is rapidly lost, coronary perfusion is diminished because of a declining aortic pressure. In contrast, intermittent MMTV with positive pressure breaths may not only inhibit venous return and be less effective breaths in terms of gas exchange, they also may diminish pressure leads to the respiratory apparatus and thus paradoxically lead to a more rapid deterioration of gasping. Therefore, continuous chest compressions may have other indirect effects that go beyond simple ejections of blood from the thorax, and they may actually result in better and more prolonged respiratory functions.

3. Recommending a modified dispatch CPR protocol

3.1. Caveats about “chest compressions-only”

While there is significant evidence to now support a CCOFs approach, particularly when dispatchers are providing instructions over the telephone for the untrained rescuer, there are still certain limitations to these data that must be appreciated and disclosed. First of all, as is usually the case, data extrapolated from animal studies should not be immediately applied to patients. For example, laboratory animals may gasp more readily and may do so for more prolonged periods of time than humans, perhaps because they receive earlier, more effective and uninterrupted chest compressions than human cardiac arrest counterparts. Also, in many of the experiments cited, the animals had “pre-intact” airways because of pre-arrest placement of tracheal tubes. In the actual clinical situation, the patient’s agonal respiratory efforts may have to overcome an occluded airway to gasp. Additionally, studies of D-CPR are more apt to involve quality assurance and protocol compliance. Evidence suggests that compliance to dispatch protocol relates to the efficiency and effectiveness of dispatch triage and instruction, making it essential to the practice of the EMD [12,51,52]. Without it, outcomes may be different.

3.2. Limitations in the scope of application

There still remains a concern that certain populations of cardiac arrest patients would benefit more from earlier MTMV or assisted breathing, including those with toxic overdose, respiratory depression, lighting strike, hanging or strangulation, drowning, smoke inhalation, allergic reactions, severe trauma, and prolonged arrest interval [53]. These conditions presumably result in asphyxia or severe hypoxemia with secondary cardiac arrest. Such patients are already hypo-perfused and presumably less likely to be gasping adequately at the time of cardiac arrest. Pediatric patients with cardiac arrest are also included in this group because respiratory failure and shock are presumably the most common causes of out-of-hospital cardiopulmonary arrest in children [54]. Therefore, standard CPR instructions are recommended under such conditions. Nevertheless, while recommended ventilation to compression ratios for children would likely remain higher than ratios for adults, experimental modeling and evolving research still point out a need for modification of future pediatric guidelines [55].

3.3. Timing and rate of lung inflation when provided

The best available data suggest that gasping respirations and chest compressions may provide adequate oxygenation and ventilation in the first few minutes (dispatch phase) after sudden cardiac arrest. However, when assimilating the best available data, there is still concern that, when they do gasp, patients may not do so for prolonged periods of time [24,29,38]. It is intuitive that, eventually, gasping should deteriorate because of the lower than normal perfusion of the brain and respiratory muscles during chest compression circulation.

Based on respiratory physiology during cardiac arrest states, it is still not clear that even patients with respiratory etiologies (whose on-scene rescuers are instructed to immediately provide MTMV) should receive compression–ventilation ratios as fast as 15:2 (or even 5:1 in children). It is generally held that the majority of those likely to survive are those who do gasp and that they can be supported by chest compressions alone for the first few minutes [24,38,44]. Nevertheless, the exact timing and indicators to provide active respiratory support (and how much support one should provide) is still not well-delineated, even in experimental models.

The available evidence indicates that the best strategy may be to provide chest compressions alone for the first 4 or 5 min following a sudden witnessed cardiac arrest and then provide some degree of lung inflation, but at a rate much less frequent than currently recommended, perhaps only once or twice a minute [42,55]. Although it may not provide the best respiratory support for some patients who do not gasp immediately (or adequately) after their cardiac arrest, it probably captures the majority of persons likely to survive [24,38,44]. More importantly, extrapolating from both clinical and experimental work, it probably enhances their chances of surviving neurologically intact [3,42].

On the other hand, some would still argue that, once ventilations are begun, current standards of 15:2 compression to ventilation ratios are still superior to lower ratios if the pauses for ventilation could be minimized [56]. In recent animal studies, 15:2 ratios appeared to be superior to 50:2 in terms of tissue oxygen delivery to the brain [56]. However, the experiments were conducted with mechanical devices that provided only 2–3 s pauses for ventilation and the authors cautioned that the data should not be immediately extrapolated to lay bystanders. Therefore, compression ratio of 100:2 or 50:2 may still be a better recommendation for dispatchers.
While a very low frequency of assisted ventilations seems to be a major departure from current CPR standards, in some respects, the introduction of some breathing after several minutes of cardiac arrest, even at a 100:2 ratio, may be considered a more "conservative" approach than the current recommendations for dispatchers which advise CCOIs (for the untrained rescuer) until professional rescuers arrive. There is a good argument that dispatchers should continue with CCOIs until rescuers arrive to avoid confusion and interruption of chest compressions. However, in the situation of prolonged responses, there is also an issue of rescuer fatigue with constant compressions over many minutes [57,58], a concept addressed in the suggested protocol (Table 1). In fact, while ratios of 50:2 may be optimal in terms of some experimental modeling [55], concerns about pauses for ventilation may be exacerbated in the novice CPR provider. Regardless, whatever the choice of compression to ventilation ratio, it is based on limited data. Therefore, more research is not only clearly indicated, but it is highly encouraged by the NAED [59].

Acknowledgments

On behalf of the Council of Standards Committee on Pre-arrival Instructions, the writing group extends their heartfelt thanks to the thousands of emergency medical dispatchers worldwide, who, on a daily basis, affect the lives of countless patients and bystanders through the caring practice of dispatch life support.

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