CARDIAC RESUSCITATION: A COMPARISON OF 30:2 AND CCC CPR ON BYSTANDER WILLINGNESS AND THE TIMING AND ROUTE OF EPINEPHRINE ADMINISTRATION

By

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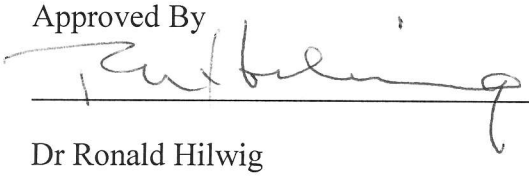

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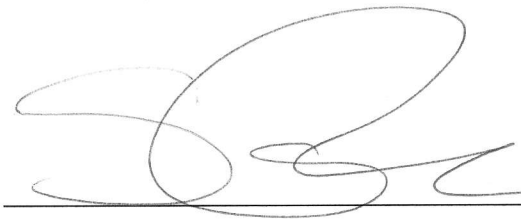
Signed: 

QUESTIONS TO BE ADDRESSED:

1. Is Continuous Chest Compression cardiopulmonary resuscitation (CCC CPR) more beneficial than the 30:2 compression to ventilation ratio when performing out-of-hospital cardiac arrest bystander CPR?
2. Is intraosseous epinephrine administration more beneficial in cardiac resuscitation than intravenous epinephrine administration?

OVERVIEW/ABSTRACT:

Since the American Heart Association suggested that out-of-hospital bystanders perform CCC CPR in 2008, many observational studies determined this method as having no beneficial significance over the traditional 30:2 compression to ventilation technique that was published in 2005. Such evidence raises the question as to whether which method bystanders should perform in order to benefit a cardiac arrest victim. Considering that one third of the out-of-hospital individuals experiencing such an event receive CPR by a lay rescuer (1), this thesis introduces and analyzes the importance of implementing CCC CPR. The simplicity of this technique will increase the occurrence of bystander CPR especially for untrained rescuers.

A recent controversy regarding whether epinephrine is a curse or a cure has raised question as to whether it should remain in the CPR algorithm. Although it aids in resuscitating an individual and bringing back a normal heart rhythm, studies have shown that it can be detrimental to the heart after a cardiac arrest. This thesis introduces the effects of the timing of epinephrine administration. It evaluates how immediate versus delayed injection of the catecholamine during resuscitation affects the rate of hospital discharge of survival. Early intraosseous infusion is more beneficial than delayed intravenous administration.

INTRODUCTION:

I. History:

"…And he went up, and lay upon the child, and put his mouth upon his mouth and his eyes upon his eyes, and his hands upon his hands; and he stretched himself upon the child; and the flesh of the child waxed warm" (13). Cardiopulmonary resuscitation attempts can

date back as early as 800 B.C. when Elijah attempted to save a child's life through mouth-to-mouth resuscitation. Techniques in saving victims experiencing events that inhibit circulation of oxygenated blood to the brain and the rest of the body have evolved since the 16th century. This is when people connected heat with life realizing that a cold body was a lifeless body. Therefore, to prevent death, these ancestors would warm the body using ashes or hot water (13).

The formality of cardiopulmonary resuscitation (CPR) can be traced back to 1740 when the Paris Academy of Sciences first recommended mouth-to-mouth resuscitation. However, it was not until 1891 when Dr. Friedrich Maass performed the first documented effective chest compression in humans (12). In 1903, the first successful use of external chest compression in human resuscitation was achieved by Dr. George Crile. In the first half of the 20th century, cardiopulmonary resuscitation became a growing popularity in the field of medicine, science, and through the United States military. Due to the growing mortality rate as a consequence of World War II, mouth-to-mouth resuscitation was advanced by the military as the American Red Cross began an aggressive education campaign to educate the American public (12). In 1960, Dr. Kowenhoven introduced the closed chest massage technique that has evolved within the past 50 years. This method was formulated to promote the transport of oxygenated blood to the brain during minimal blood circulation. During that year, the American Heart Association also started a program to educate physicians about the importance and formal technique of closed-chest cardiac resuscitation (13). Three years later, the Association formally endorsed CPR. Believing that the resuscitation techniques were easy enough for the public to perform during out-of-the hospital emergencies, Leonard Cobb held the first citizen CPR training in Seattle in 1972 (12). This method of mass citizen education was further advanced in 1981 when the American Heart Association provided telephone instructions in King County, Washington (13).

Since the formal endorsement of CPR, this technique has evolved heavily within the past 50 years. With advanced research and experience from the application of the technique, CPR

has transformed based on the issue that is requiring bystander or medical resuscitation. Also, advanced on the scene support has contributed to the rapidly evolving method (12).

II. CARDIAC ARREST

Each year, the Emergency Medical Services (EMS) treats an average of 295,000 out-of-hospital victims that are experiencing a cardiac arrest. From that statistic, less than 8% of these individuals leave the hospital alive (1). Unlike other muscles, the heart has its own electrical stimulator, the sinoatrial node. Located in the upper right atrium, this collection of cells generates electrical impulses that flow in an orderly manner from the base to the apex of the heart. It is this organized manner that synchronizes the heart rate and thus coordinates the pumping of the blood. Sudden cardiac arrest is defined as an unexpected loss of heart function, breathing, and consciousness due to an electrical disturbance with the sinoatrial node or the flow of the electrical impulses through the heart (5). If long lasting, this disturbance can lead to abnormal heart rhythms known as arrhythmias. When the heart beats too fast, too slow, or stops, it disrupts the pumping action thus inhibiting or minimizing blood flow to the rest of the body, primarily the brain. Consequentially, the low pumping of oxygenated blood can cause brain damage in a few minutes. Within four to six minutes from the onset of sudden cardiac arrest, death or permanent brain damage will occur if CPR or advanced life support is not placed upon the victim (5).

The symptoms related to sudden cardiac arrest are sudden and drastic and unfortunately occur with no warning. Some that may precede the event are fatigue, fainting, chest pain, palpitations, and blackouts. At the onset of an arrest, loss of consciousness, lack of pulse, and the ceases of breathing will occur (5). However, often, arrhythmias do not occur on their own. For example, in a healthy heart, the event of a cardiac arrest due to electrical disturbances may happen due to the use of illegal drugs, severe trauma to the chest, or an electrical shock that may elicit a lasting irregular heart beat. In unhealthy hearts, sudden cardiac arrest can occur due to heart disease or heart attacks (5).

III. 2005 GUIDELINES

In 2005, it became imperative that the American Heart Association reduce the amount of information the rescuers must learn. These guidelines focused on the universal idea, "push hard, push fast, allow full chest recoil, and minimize interruption in chest compressions (6)." Based on studies that focused on the effectiveness of the 2000 guidelines, the authors realized that there were four main factors pertaining to CPR that helped guide the formulation of the 2005 guidelines. First, to promote effectiveness, CPR must be started as soon as possible. Also, studies showed that performing chest compressions without ventilation by a bystander was better than doing nothing. This contributed to the third factor which showed that due to lack of confidence of their ability to perform adequate CPR, lay bystanders are reluctant. This lack of confidence is commonly due to the idea that the resuscitation technique is too complicated or their training was inadequate. Some bystanders hesitate to perform rescue methods simply because they have fear of contracting a disease from mouth-to-mouth ventilation. The fourth factor focused on having trained and motivated bystanders with short response times in order to yield best results for out-of-the-hospital CPR (6).

The ABCD approach was emphasized to provide basic life support for acute cardiopulmonary arrest. Therefore, in the event of a victim experiencing cardiac arrest, it was advised that a bystander open the airway (A) using a head-tilt chin-lift method (17). In this technique, the rescuer places backward pressure on the casualty's head and tilts it back causing the chin to point upwards. The chin is then lifted upward. After the airway has been opened, the bystander checks to see if the victim is breathing (B). However, unlike the 2000 guidelines, in 2005, the Association required that breathing be checked only in nonresponsive individuals. Circulation (C) is the third step followed by the final step. defibrillation (D) (6). Both of these steps focus on the actual resuscitation of the medically troubled person both promoting circulation of oxygenated blood to threatened organs like the brain and restoring the heart's normal rhythm.

With the hopes of yielding a higher survival rate for victims experiencing cardiac arrest, the Association wanted to ensure a longer period of uninterrupted chest compressions.

Therefore, the ratio of chest compression to ventilation changed from 15:2 to 30:2 (6). By raising the ratio, blood circulation increased as the number of uninterrupted chest compressions increased. Doubling the CPR ratio allowed a higher chance of achieving significant coronary and cerebral perfusion (6).

To satisfy the goal of simplifying the education of CPR to the general public so that they could feel confident enough to perform this resuscitation technique, the guidelines state that lay rescuers are no longer required to assess for signs of circulation before beginning external chest compressions. This was because studies show that bystanders are often unable to determine whether circulation is present. As a consequence, they may not provide the chest compressions when needed or in a timely manner. Since some rescuers do not feel comfortable with performing mouth-to-mouth resuscitation, the guidelines also eliminated the requirement that rescuers must provide breathing between chest compressions (6). Therefore, beginning in 2005, ventilation became optional.

Finally, unlike the 2000 guidelines which required three stackable shocks by an AED, in 2005, this number reduced to one shock when required. Therefore, after an AED checked for a shockable rhythm, if a shock is required, the casualty would only receive one with CPR being resumed for five cycles (6).

In conclusion, the 2005 algorithm for adult basic life support for an individual experiencing cardiac arrest emphasizes minimal interruptions to chest compressions, minimal pulse checks, and minimal interruptions to CPR. By minimizing interruptions, it was hoped that the maximum benefits of compressions would occur and the rate of survival would increase in comparison to the 2000 guidelines.

IV. 2010 GUIDELINES

Like the guidelines in 2005, the American Heart Association analyzed the performance, outcome, and effectiveness in order to improve the survival rate for the 2010 CPR methods for individuals experiencing a cardiac arrest. Minimizing interruptions in effective external chest compressions became a key point for this time period. According to Dr. Karl Kern,

studies show that when interrupting the compression action of CPR due to ventilations, these interferences took 16 seconds to complete thus taking away valuable time for effective manual blood flow to occur (2). This interruption decreases the survival rate because it requires a new build up of coronary and cerebral pressure. Also, the guidelines aimed to minimize the importance of pulse checks considering that detections by a lay bystander can be difficult and compressions to patients that were not experiencing cardiac arrest rarely lead to injury (2).

As of 2007, one in four patients experiencing cardiac arrest received bystander CPR. This was because lay rescuers were less likely to start resuscitation efforts when mouth-to-mouth ventilation was required by the American Heart Association guidelines (2). In 2010, the sequence of cardiac resuscitation changed from airway-breathing-compressions (ABC) to compressions-airway-breathing (CAB). Research has shown that the traditional 30:2 CPR method was not the most beneficial way to treat cardiac arrest (2). According to Dr. Gordon Ewy, a person who collapses due to sudden cardiac arrest was usually breathing normally seconds before the event occurred. Therefore, there was no point in administering the 16 seconds delay in start of chest compression through ventilation because the victim's blood and lungs are already full of oxygen. Further studies found that the blood contained within a cardiac arrest individual had enough oxygen to sustain the normal activity of the brain and heart for minutes. Therefore it is imperative that circulation to the brain and other major organs should start immediately so that the oxygenated blood can continue to supply these vital systems (2).

On April 1, 2008, the American Heart Association encouraged chest compression only CPR (CCC CPR) to be performed by untrained lay rescuers. It was believed to be easier to perform and less complex as the actual technique required two steps. First, the lay rescuer should apply pressure straight down on the middle of the sternum of the unresponsive victim. This pressure to the heart between the sternum and the spine forces blood to the aorta and pulmonary artery. Finally, the bystander should perform 100 chest compressions per minute until he fatigues or EMS arrives (2). Rescue breathing was not recommended for cardiac

arrest because even when chest compressions are continuously performed, the blood flow generated by this technique is so weak that any interruption would hinder the chance of survival. Also, the depth of performing a chest compression changed between these two time periods. In 2005, it was advised for the rescuer to perform a compression that was between 1.5 and 2 inches deep. However, in 2010, studies showed that a compression that was at least 2 inches was more effective since it would supply more adequate blood flow and pressure to the heart (2).

V. EPINEPHRINE AND ITS ROLE IN CPR

In 1901, chemist, Jokichi Takemine, isolated the hormone, epinephrine (8). Also known as a catecholamine and vasopressor, the adrenal medulla produces large amounts of this hormone during times of excitement, danger, and emotional stress. To stimulate the "fight or flight" response of the sympathetic nervous system, it raises the blood pressure, constricts small blood vessels, and relaxes certain unused involuntary muscles (8).

Since the establishment of the American Heart Association, the use of epinephrine during cardiac resuscitation has been implemented in algorithms for decades (9). Research has shown that the key to a successful resuscitation is to increase coronary perfusion pressure. According to recent animal studies, early administration of a vasopressor, like epinephrine, during a cardiac arrest event experiencing ventricular fibrillation is crucial for achieving adequate perfusion pressures to important organs. By achieving this pressure through the help of this hormone, the likelihood of a successful defibrillation and good neurological outcome increases (9).

Epinephrine is a mixed adrenergic agonist that affects both the alpha and beta receptors (9). When the catecholamine binds to the alpha receptors, peripheral vasoconstriction occurs thus shunting blood away from organs like the skin and moving it towards visceral and cerebral regions. This causes a shift in blood volume and increases pressure on the system thus creating pressure in the aorta, the driving force of coronary perfusion pressure (9). When bound to the beta receptors, this induces a positive inotropy and vasodilates the

coronaries. However, when bound to beta receptors during a cardiac arrest, adverse effects can occur such as increased myocardial consumption, ventricular arrhythmias, and postresuscitation myocardial dysfunction (8,9).

REVIEW PROCESS AND LITERATURE SEARCH PERFORMED:

PubMed and Google Scholar searched for studies including patients or out-of-hospital scenarios that compared receiving chest compressions with ventilations to chest compressions without ventilations during cardiac resuscitation. The continuous chest compression group must have been separated from other groups in the analysis to be included. Outcomes had to be clearly defined and had to included some of the outcomes of interest mentioned below. Animal studies were included.

PubMed and Google Scholar searched for studies including patients that focused on the timing of epinephrine administration during cardiac resuscitation. These studies compared immediate to delayed infusion as well as the route of infusion- intraosseous versus intravenous. The outcomes had to be clearly defined and had to include some of the outcomes of interest mentioned below. Animal studies were included.

PUBMED AND GOOGLE SCHOLAR SEARCH WITH THE FOLLOWING TERMS:

SEARH TERM: bystander willingness and cardiopulmonary resuscitation and cardiac arrest

522 results, 3 kept

SEARH TERM: cardiopulmonary resuscitation and continuous chest compression and 30:2

1,330 results, 4 kept

SEARCH TERM: epinephrine and timing

6 results, 1 kept

SEARCH TERM: epinephrine and intraosseous infusion and intravenous infusion

8 results, 2 kept

CRITERIA FOR CONSIDERING STUDIES FOR THIS REVIEW:

OUTCOMES- Neurologically intact survival at hospital discharge, ROSC, survival at hospital discharge

SCIENTIFIC FOUNDATION FOR CCC CPR VS 30:2 CPR:

Understanding that one third of the out-of-hospital cardiac arrest victims receive bystander resuscitation before emergency arrival (1), the objective of the Coons et al study was to identify the barriers to bystander CPR in Arizona. After analyzing 370 completed questionnaires, the study showed that 50% of the participants were willing to perform CPR on a stranger while 80% would be a lay rescuer for a family member (7). Among the individuals that have been educated in cardiac resuscitation, 55% stated that they were willing to perform out-of-hospital CPR. Although reasons as to why there was a 30% difference between helping a stranger and a family member, these results show that there is a large barrier towards assisting cardiac arrest victims (7).

A similar study was conducted to determine the attitudes towards and obstacles performed by lay rescuers. After surveying 975 students at the University of Arizona, 82% of the respondents said they did not want to face the possibility of potential disease transmission during mouth-to-mouth ventilation (14). Further, among the participants, only 15% said they would "definitely" perform the standard 30:2 CPR mechanism that requires 30 chest compressions and 2 breaths. In comparison, if they learned CCC CPR, 68% responded that they would "definitely" perform this new method (14). Past studies have already shown that if an out-of-hospital patient experiencing a cardiac arrest receives immediate CPR, there is a higher chance of survival. It is conclusive that the majority of the population is not willing to perform bystander CPR when mouth-to-mouth ventilation is required. However, this willingness to perform almost triples when that resuscitation factor is eliminated. Therefore, these results open the idea that CCC CPR is important for improving the survival rate for cardiac arrest.

Since the current rate of bystander CPR is low due to the common fear of disease transmission and of not performing the technique correctly, the effectiveness of CCC CPR in

comparison to the standard method was evaluated to determine if the new technique could be used as a substitute when performing out-of-hospital CPR. In a study performed by Bobrow et al, the objective was to investigate the survival of patients with out-of-hospital cardiac arrest using CCC CPR compared with the conventional method. In this five year Arizona study, 4415 people above the age of 18 were assessed. From this number of participants, 2900 received no bystander CPR while 660 received 30:2 standard CPR and 849 experienced the CCC technique (4). When analyzing the rates of survival to hospital discharge, both the conventional and new method were better than receiving no resuscitation attempt. However, when comparing the standard CPR to CCC CPR, with a result of 13.3%, the new technique had the highest rate of survival. The conventional method had a discharge rate of 7.8%. Also, from 2005 to 2009, conventional CPR performed by out-of-hospital witnesses increased from 28.2% to 39.9% (4). However, lay rescuer CCC CPR almost quadrupled as it rose from 19.6% to 75.9%. Overall, during this five year study, out-of-hospital survival due to a cardiac arrest increased from 3.7% to 9.8% (4).

A similar study conducted by Hallstrom et al had two objectives. The first goal was to compare bystander willingness when performing out-of- hospital cardiac resuscitation. Among the 520 cases that received CPR by a lay rescuer with the help of a telephone dispatcher, 279 were randomly assigned to perform the conventional 30:2 CPR method while 241 attempted CCC CPR (11). Out of the 520 cases, 62% of the rescuers that were assigned the traditional technique completed the instructions until EMS arrived. In comparison, 81% of the bystanders that were assigned CCC CPR completed the new method. Also, results showed that callers receiving the instructions with chest compressions and ventilation were 4.3% more likely to terminate resuscitation attempts by ending the conversation or stating the technique was too difficult (11). The second objective focused on comparing the rate of survival of hospital discharge between the standard and new methods. Of the 64 out-of-hospital patients that survived, 10.4% had received and survived from the 30:2 CPR while 14.6% received and survived from CCC CPR (11). Overall, this study showed that instructions for CCC CPR were more useful than 30:2 guidelines and the new technique was more effective in terms of survival.

Like the Hallstrom et al study, Rea et al conducted a similar experiment by randomly assigning telephone dispatchers to provide 30:2 or CCC CPR instructions to 1941 patients. The aim of this study was to compare the rate of survival to hospital discharge and favorable neurological outcome of the individuals that experienced an out-of-hospital cardiac arrest (16). Although the results were not significant, it showed slight emphasis on CCC CPR and minimal rescue breathing when performing cardiac resuscitation by laypersons. For example, the rate of survival to hospital discharge was 1.5% higher for the victims that received CCC CPR in comparison to the 30:2 method. The individuals that received the new instructions had a 3.9% more beneficial result in terms of a favorable neurological outcome in comparison to those who received the conventional technique (16).

The final study of interest was conducted by Ewy et al. Using swine to model an out-of-hospital scenario, this research focused on the neurological outcome 24 hours after ventricular fibrillation and the mean coronary perfusion pressures during and one day after CPR performance (10). From the 64 domestic swine, 33 received CCC CPR while 31 received 30:2 CPR. 70% resulted in a 24 hour neurological outcome of 1 or 2 while 42% of the standard CPR participants survived with the same favorable outcome. A neurological outcome of 1 represents the swine as being normal while an outcome of 2 means that the subject is slightly abnormal (10). Return of spontaneous circulation (ROSC) occurs when the subject has an aortic pressure above 50mmHG and a pulse pressure above 20mmHG for one minute. When comparing the mean coronary perfusion pressure, a characteristic that is most significant in cardiac resuscitation, at the event of CPR, CCC revival generated an average of 20mmHg while 30:2 technique only produced a pressure of 14mmHg (10). The mean coronary pressure for the new method continued to be higher than the standard instructions 24 hours after the onset of the cardiac arrest. However, the difference was more significant considering that CCC CPR resulted in an average 23mmHg pressure while the 30:2 CPR generated 10mmHg (10).

In summary, bystander willingness to perform cardiac resuscitation on an out-of-hospital victim increases when given the option of performing chest compressions without

ventilations. Although studies show that the most common reason is due to the concern of transmitting diseases based on this physical contact and fear of incorrectly executing the resuscitation method, the complexity of performing the 30:2 compression to ventilation technique is also a barrier that hinders the survival rate for cardiac arrests. Also, current research continues to support the idea that maintaining coronary perfusion pressure is the most imperative factor in resuscitating an individual as results show that maintaining continuous chest compressions without ventilation interruptions creates a higher rate of survival to hospital discharge and neurological outcome.

SCIENTIFIC FOUNDATION FOR THE TIMING AND ROUTE OF EPINEPHRINE ADMINISTRATION

Within the past decade, there has been an ongoing controversy regarding the beneficial effects of epinephrine during cardiac resuscitation. In many animal studies, early administration of epinephrine has shown improved coronary perfusion pressure, enhanced potential for successful defibrillation, and improved survival after cardiac arrest. However, clinical studies have been unsuccessful in expressing improved outcome after the administration of epinephrine in an out-of-hospital cardiac event. One study showed that as the duration of the cardiac arrest continued, the administration of epinephrine became increasingly more important in order to achieve ROSC. However, this correlation also showed that the drug of choice was increasingly associated with post-ROSC myocardial dysfunction (3). Using Sprague-Dawley rats, three series of traditional CPR were performed after 2, 4, and 6 minutes of the cardiac arrest. In this study, epinephrine was immediately given in the groups that received CPR after 2 and 4 minutes. However, the administration of the drug was delayed for the group that experienced a cardiac arrest for 6 minutes (3). After comparing the ROSC between the three groups, although epinephrine infusion created better results in comparison to the placebo subjects, all rats in the 2 minute group had a significantly higher cardiac index while 81% of the participants in the 6 minute group had the largest post-ROSC depression of cardiac index (3).

One possible reason as to why animal studies have proven success while clinical studies have not is the time of epinephrine administration. Placing an intravenous line in a cardiac arrest victim can be difficult and almost impossible especially if the individual is receiving CPR. In a study performed by Zuercher et al, intraosseous (IO) and intravenous (IV) drug infusion were compared in a realistic scenario of prolonged ventricular fibrillation due to a cardiac arrest (18). There were three groups that the 30 swine subjects were randomized into: IO epinephrine, IV epinephrine, and placebo. The outcomes that this study focused on were ROSC, 24 hour survival, and 24 hour survival with good neurological outcome (18). Overall, the two groups that received epinephrine yielded better results than the placebo group. This suggests, that drug administration during cardiac resuscitation should continue. When comparing the IO and IV groups, results pertaining to the achievement of ROSC after 10 minutes of untreated ventricular fibrillation was insignificant. However, all the swine survived 24 hours after the onset of the cardiac arrest in the IO group while only 4 survived in the IV group. Also, in comparison to the IV group, the IO group had 3 more subjects that survived 24 hours with a neurological outcome of 1 or 2 (18). Overall, this study showed that prolonged ventricular fibrillation during a cardiac arrest requires epinephrine administration. Also, although the time between injection and peak coronary perfusion pressure was slightly longer in the IO group, early administration showed to have improved long term results in comparison to the delayed IV infusion (18).

In the final study, swine models were placed in an out-of-hospital scenario and underwent prolonged ventricular fibrillation. They were randomly placed in two groups, intraosseous epinephrine administration with continuous chest compressions (CCC IO) and intravenous infusion with conventional 30:2 CPR (CPR-IV) (15). After experiencing 10 minutes of untreated ventricular fibrillation, the results showed that the mean time for IV drug infusion during CPR performance was 6.68 minutes while it was 0.84 minutes for IO. Overall, the CCC-IO group had a significantly better outcome in achieving peak coronary perfusion pressure, ROSC, and 20 minutes of survival in comparison to CPR-IV (15).

In summary, although the studies regarding the timing of epinephrine infusion during cardiac resuscitation is limited, research has already shown that this drug of choice is imperative in restoring the heart rhythm of an arrested victim. Also, it has opened the idea that early rather than delayed epinephrine infusion can ultimately result in a better survival outcome and therefore the intraosseous route should be the method of choice. This is considering that it is less difficult than inserting an intravenous line.

LIMITATIONS

Additional studies are required to see if the CCC CPR method is more beneficial than the standard 30:2 CPR technique when performing cardiac resuscitation on an out-of-hospital victim. Currently, the established instructions published in the 2010 American Heart Association guideline are based on consensus and not science. This is because there lacks the funding to perform a study that incorporates the comparison between the new and the conventional CPR methods on a mass population. Without such a study, the support that CCC CPR is more advantageous than 30:2 CPR, especially for lay rescuers, will remain a consensus. Also, more clinical studies are required because researchers cannot 100% equate the results of animal experiments towards how the techniques will affect the human population.

Additional studies on humans are also required to determine if the timing of epinephrine administration during cardiac resuscitation affects the post arrest results of an out-of-hospital victim. More clinical studies pertaining to the route of administration are needed. There are large discrepancies between humans and animals in terms of the timing of infusion. Also, many of the present studies administer epinephrine at different stages thus limiting the actual results of its benefits and detrimental effects to the heart.

RECOMMENDATIONS AND STRENGTH

Standards: Perform chest compressions with or without ventilations on out-of-hospital cardiac arrest victims. Administer epinephrine during prolonged ventricular fibrillation.

Options: Out-of-hospital bystanders should perform continuous chest compressions on cardiac arrest victims. Epinephrine should continue to be the drug of choice during prolonged ventricular fibrillation and should be administered through the intraosseous route.

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