Have the latest CPR guidelines improved cardiac arrest outcomes?

The question has always been whether CPR and ACLS protocols make a difference for victims of cardiac arrest. Outcome data are now becoming available to answer this question.

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Since the Standards for Cardiopulmonary Resuscitation and Emergency Cardiac Care were introduced in 1974, several updates to these guidelines have been issued.[1-7] Over this time, the guidelines have come full circle, moving from simple to complicated to simple again. This article compares changes to the guidelines over the years, presenting the evidence and reasoning behind the changes. Current outcomes data are discussed, with emphasis on what is effective in improving survival. The article stresses the importance of high-quality cardiopulmonary resuscitation (CPR), early defibrillation, and the need to train the lay public to recognize cardiac arrest and implement CPR.

A BRIEF HISTORY OF CPR

The currently used closed chest massage for CPR was developed and introduced by William Kouwenhoven in 1958, although some form of the technique had been used by Friedrich Maass and others dating back to the1800s.[1] Artificial respiration has been documented as far back as the 6th century. Modern CPR caught on in the early 1960s because of the fairly simple technique of mouth-to-mouth breathing and closed chest massage.[1] The changes in CPR coincided with developments of new advanced cardiac life support (ACLS) guidelines over the years. Changes in compression and ventilation rates are given in **Table 1.**

The main changes to the CPR guidelines over the years have consisted of increases in compression rate, decreases in ventilation rate, and, in 2005, a uniform compression-to-ventilation ratio of 30:2 for all ages older than neonates. The recommended ventilation rate decreased because the earlier rates had been determined to cause hyperventilation, which increases thoracic cavity pressure and cerebral pressure and decreases venous return and coronary perfusion pressures.[1] A ventilation rate of 10 to 12 breaths per minute, or 8 per minute with an advanced airway in place, is currently recommended.[1]

In 2000, the pulse check was eliminated for laypersons[6] because a few small studies had indicated that even medical professionals have difficulty identifying a pulse on an unresponsive victim.[8] Experts concluded that it is better to perform

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CPR on a person who has a pulse than to withhold resuscitation from a victim who is pulseless.[9] The time spent trying to feel for a pulse in an unresponsive victim significantly delays the start of chest compressions. In other studies, agonal respirations are often misinterpreted by lay persons as "breathing," which also delays intervention in sudden cardiac arrest. The 2005 American Heart Association (AHA) CPR guidelines therefore began to teach laypersons to begin CPR if a victim is unresponsive and not breathing normally.[7] The pulse check remains in the protocol for health care providers.[7]

Compression-to-ventilation rates remained at 15:2 from 1974 to 2005, until it became clear that pausing compressions to give ventilations resulted in significant delays in compressions. A porcine research study demonstrated a 30% improvement in cardiac output and cerebral blood

Summary pearls

- Pulse checks by laypersons are discouraged.
- Bystander chest compression-only CPR improves survival in witnessed sudden cardiac arrest.
- Interruptions in CPR should be minimized.
- Ventilation in the first 4 minutes of a ventricular fibrillation/ventricular tachycardia (VF/VT) arrest is less critical.
- Early defibrillation in VF/VT arrest is critically important.
- Biphasic defibrillators are more effective converting VF.
- Implementing public CPR training and automated external defibrillator programs are improving survival rates.

flow with a 30:2 compression to ventilation rate.[10] The 30:2 rate was thus recommended by consensus for the 2005 guidelines.[7,10]

In 2007, the Resuscitation Outcomes Consortium (ROC) showed preliminary evidence from an observational study that a higher CPR fraction (the length of time that chest compressions are done during a resuscitation episode) has a direct impact on survival to discharge.[11] Victims with a 0% to 20% CPR fraction had an 8.6% survival-to-discharge rate, as compared to a 34.2% survival-to-discharge rate for those with a CPR fraction of 81% to 100%.[11] A prospective study of 97 in-hospital resuscitations proved that compression rates were less than the recommended amount, even by trained hospital personnel.[12] For 36% of the resuscitation time, compression rates were less than 80 per minute; and for 27% of the time, the rates were less than 70 per minute. Higher compression rates were significantly correlated with initial return of spontaneous circulation.[12]

MINIMALLY INTERRUPTED CARDIAC RESUSCITATION

A prospective study of cardiac arrest victims, conducted in two metropolitan cities in Arizona, looked at minimally interrupted cardiac resuscitation (MICR) compared to standard 2000 AHA emergency medical services (EMS) protocols.[13] Of 878 cardiac arrests, 218 occurred before introducing the MICR protocol. Four of these 218 (1.8%) survived to hospital discharge. Of 668 cardiac arrests treated with the MICR protocol, 36 survived (5.4%). Patients with witnessed ventricular fibrillation (VF) had a 28.4% survival rate with MICR as compared to 11.9% with standard EMS protocol.[13] The MICR protocol, developed by the University of Arizona Sarver Heart Center, is highlighted in **Table 2**.

In 2009, Garza and colleagues described the Kansas City, Missouri, EMS system retrospective cohort study comparing the results of using the 2000 guidelines to the results of using a modified, "minimally interrupted" protocol.[14] The goal was to improve survival to hospital discharge in victims of sudden VF or pulseless ventricular tachycardia (VT) arrest. The protocol was similar to the Arizona protocol detailed in **Table 2**. The main differences were use of a 100% nonrebreather mask and oral airway for oxygenation with a 50:2 compression-to-ventilation rate. Ventilations were given by squeezing the reservoir bag on the mask. A 10-second intubation attempt was performed after three complete CPR cycles. EMS personnel used only manual defibrillators because of the delay incurred when an automated external defibrillator (AED) is in analysis mode. With these changes, survival rates improved from 7.5% to 13.9%.[14]

CHEST COMPRESSION-ONLY CPR

In 2008, the AHA issued a call to action for the general public, whether trained in CPR or not, asking for bystanders to take action when recognizing an unresponsive person.[15] The action includes calling for help and, if the victim is not breathing normally or responding, starting compression-only CPR.[15]

Since 1997, five human studies have evaluated compression-only CPR and concluded that survival to hospital discharge is similar in persons treated with compression-only CPR and those treated with conventional CPR with rescue breathing.[16-20] Three of the published studies indicated that the end point of 30-day survival with good neurologic function was similar in both groups.[18-20] Chandra and colleagues reported in a canine study that chest compressions only during a VF arrest can maintain oxygenation greater than 90% in the first 4 minutes; after that, ventilations are needed to maintain oxygenation.[21]

KEY POINTS

- Historically, many recommendations for cardiopulmonary resuscitation (CPR) and emergency cardiac care (ECC) have been made by expert consensus based on animal studies because there were few randomized controlled trials in humans.
- Now, however, data emerging from large human trials such as the Resuscitation Outcomes Consortium and the Save Hearts in Arizona Registry and Education program have demonstrated that quality chest compressions with less emphasis on ventilation are key to improving survival rates for victims of sudden cardiac arrest.
- By the time that new CPR/ECC guidelines come out in 2010, a wealth of human resuscitation outcomes data will have been made available to inform the guidelines committee; and recommended changes will likely include continuous chest compression CPR.
- It is critical for health care providers to remain current regarding standards and guidelines for basic life support and for efforts to develop public CPR training and automated external defibrillator programs to continue.

TABLE 1. American Heart Association CPR protocol from 1974 to 2005

	Compression to ventilation rate	Rate of compression	Initial breaths	Ventilation rate
1974	• 1 rescuer: 15:2 • 2 rescuers: 5:1	60/min 80/min	"4 staircase"	12
1980	Same as 1974	Same as 1974	Same as 1974	Same as 1974
1986	Same as 1974	80-100/min	2 "full" breaths	Same as 1974
1992	Same as 1974	Same as 1986	Same as 1986	10-12/min
2000	1 & 2 rescuers: 15:2	100/min	2 breaths	Same as 1992
2005	1 & 2 rescuers: 30:2	100/min	2 breaths	• 10-12/min • 8-10 with advanced airway

Data from standards and guidelines references.[2-7]

The canine study suggests that ventilations are not as important early in a VF/VT arrest. In asphyxia, drowning, drug overdose, or pediatric arrest, however, ventilations are recommended immediately. A 2007 study in Japan of 2,698 sudden cardiac arrest victims revealed more favorable neurologic outcomes for patients who received chest compression-only CPR versus chest compression and mouth-to-mouth ventilation.[19]

The call to action by AHA is an effort to reduce barriers to bystander intervention if onlookers identify an unresponsive person.[15] If bystanders activate the EMS system immediately and begin chest compressions, and if first responder/AED response time is less than 5 minutes, better survival rates should be seen.

DEFIBRILLATION

In witnessed sudden cardiac arrest, defibrillation should occur as soon as possible. Current guidelines call for a single shock followed by 2 minutes of CPR before the pulse check.[7] The 2000 guidelines called for a series of three "stacked" shocks for VF/pulseless VT, which resulted in significant delays in compressions.[6] The three-shock sequence and analyzing modes of commercial AEDs also significantly delay compressions. White and colleagues demonstrated that the 2005 CPR guidelines resulted in fewer shocks and more compressions.[22] In their small, regional EMS system study, total defibrillations were reduced from 4.5 to 2.8, and compressions were increased from 47 to 75 per minute; the pause following a shock was reduced from 48.7 to 11.8 seconds.[22]

TABLE 2. Minimally interrupted cardiac resuscitation

200 uninterrupted compressions (100/min)
Rhythm analysis
200 immediate postshock compressions
Pulse check/rhythm analysis
Intubation delayed until after 3 complete cycles
Epinephrine 1 mg IV ASAP, repeated after each cycle

Data from Bobrow BJ et al.[13]

The BIPHASIC Trial in 2007 demonstrated that escalating doses of energy from a biphasic defibrillator (200-300-360 joules [J]) were more effective in converting VF than fixed low-dose defibrillations (150-150-150 J) in patients who required more than one defibrillation.[23] First shock conversion rates of VF with the new biphasic defibrillators can reach 90%.[23]

PUBLIC AUTOMATED EXTERNAL DEFIBRILLATOR PROGRAMS

For each minute a victim has VF, the person's chances of survival decrease by 7% to 10%.[1] The importance of early recognition, immediate CPR, and immediate use of an AED is well-recognized. A 2007 study of 11 participating centers in the ROC found that for victims of out-of-hospital cardiac arrest, when CPR was started by bystanders and an AED applied with a shock delivered, survival to discharge from the hospital was 33% (n = 9,897).[24]

Hazinski and colleagues describe the results of the Public Access Defibrillation Community Trial, where 993 public facilities in 24 urban areas were randomly allocated to provide CPR only or CPR plus AED resuscitation for victims of sudden cardiac arrest.[25] Key elements of this study included a 3- to 15-minute EMS response time, a defined geographic area, and the ability of AED sites to deliver the AED to a victim within 3 minutes. For this study, 20,000 volunteers were trained in CPR, and 1,600 AEDs were placed in public places. The results: 15 out of 107 (14%) victims survived to hospital discharge in the CPR-only group; in the CPR plus AED cohort, 30 of 128 (23%) victims survived to hospital discharge.[25] This study supports the AHA recommendation for public AED programs and rigorous CPR training for the lay public. Extrapolation of the data to the general population suggests that 2,000 to 4,000 lives per year could be saved from bystander CPR and AED implementation.[26]

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TABLE 3. Ventricular fibrillation cardiac arrest survival rates by region

Alabama	7.7%
Dallas	9.5%
Iowa	23%
Milwaukee	26%
Ottawa	15%
Pittsburgh	21.5%
Portland	22.5%
Seattle	40%
Toronto	15.7%
Vancouver	25%

Data from Nichol G et al.[35]

EMERGENCY PHARMACOLOGY: ANTIARRHYTHMICS AND VASOPRESSORS

To date, no evidence in human studies indicates that administering antiarrhythmic drugs or vasopressors at any time during a cardiac arrest improves survival to hospital discharge. In a meta-analysis of five randomized trials, Aung and colleagues reported no difference between vasopressin and epinephrine in return of spontaneous circulation or survival to hospital discharge.[27] Amiodarone, a ventricular antiarrhythmic, produced improved short-term survival to hospital admission–but not survival to hospital discharge–when compared to placebo and lidocaine.[28,29] Prior to submission of the 2005 guidelines, a proposal was made to remove all recommendations for vasopressors. The proposal was not approved in the absence of placebo-controlled trials in humans and because of evidence from animal studies that vasopressors do have physiologic benefits.[27] In 2008, an Austrian study showed that the cumulative dose of epinephrine given in a non-VF arrest is independently associated with higher mortality.[30] A median dose of 4 mg produced higher mortality than a median dose of 2 mg.[30]

CURRENT RESUSCITATION OUTCOMES RESEARCH

Researchers in Oslo, Norway, investigated whether the quality of CPR improved after the 2005 guidelines were introduced by comparing 435 patients treated during a 2-year period before the 2005 guidelines were released and 481 patients after the release.[31] Improvements seen when the 2005 guidelines were used included the following: Preshock pauses decreased from a median of 17 seconds to a median of 5 seconds; chest compression rates decreased from 120±9 to 115±10 per minute; and ventilation rates decreased from 12±4 to 10±4 per minute. The overall survival to hospital discharge increased from 10.3% to 13.1% after the 2005 guidelines were released, indicating that CPR quality improved and survival rates increased for this study.[31]

In St Cloud, Minnesota, and Anoka County, Minnesota, widespread CPR training in schools and workplaces along with retraining of EMS personnel enabled 12,000 people to obtain CPR training.[32] This training, plus the implementing of public AED programs in these areas, improved survival rates from 9.3% to 17% from 2005 to 2007.[32]

CPR BEFORE DEFIBRILLATION?

The researchers of the ROC evaluated 2,913 VF/VT arrests occurring from 2005 to 2007.[33] They compared a control group of victims that had less than 45 seconds of initial CPR to those victims who had 46 to 195 seconds of CPR before defibrillation. The group with chest compressions from 46 to 195 seconds prior to defibrillation had improved survival to discharge.[33]

HYPOTHERMIA IN THE POSTRESUSCITATION PERIOD

Postresuscitation hypothermia has been investigated for at least 10 years, and randomized trials comparing hypothermic to normothermic management have produced encouraging findings. In two trials in which postcardiac arrest patients' temperatures were reduced to 89°F to 93°F, improvements in survival to hospital discharge and neurologic function at 6 months were seen.[10,34] Recommendation for hypothermia after return of spontaneous circulation was made by consensus, and the recommendations are being implemented in many parts of the country. The need for more research continues.

SURVIVING CARDIAC ARREST: IT ALL DEPENDS ON WHERE YOU LIVE

The survival rates for out-of-hospital sudden cardiac arrest (OHSCA) vary greatly by region.[35] For VF arrest rates, survival varies from 7.7% to 39.9%.[35] In a 2008 report from the ROC, survival rates of all EMS-treated OHSCA ranged from 3% to 16.3%[35] (**Table 3**). On a local level, many factors can contribute to these differences, including EMS response times and postresuscitation care in hospitals.[35] Two leading resuscitation researchers suggest that communities implement the following recommendations to improve survival rates: (1) develop a community cardiac arrest registry; (2) establish rapid dispatch for cardiac arrest; (3) implement dispatcher-telephone CPR instructions; and (4) promote early defibrillation.[36]

> "The data suggest that minimally interrupted, high-quality chest compressions with less emphasis on ventilation improve survival."

CONCLUSION

Historically, many recommendations for emergency cardiac care (ECC) have been made by expert consensus based on animal studies because there were few randomized controlled trials in humans. Now, however, data emerging from large

human trials have demonstrated that minimally interrupted quality chest compressions with less emphasis on ventilation are key to improving survival rates for victims of sudden cardiac arrest. By the time that the new ECC and CPR guidelines are issued in 2010, a wealth of human resuscitation outcomes data will have been made available to inform the guidelines committee; and recommended changes will likely include continuous chest compression or minimally interrupted CPR. Most importantly, it is critical for health care providers to remain current regarding standards and guidelines for basic life support and for efforts to develop public CPR training and AED programs to continue. JAAPA

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