New Insights Into Effective CPR: Cardiocerebral Resuscitation for Primary Cardiac Arrest

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Cardiocerebral resuscitation is a new approach to patients with primary cardiac arrest that has been shown to dramatically increase survival. The term cardiocerebral *is used to stress that the issue is immediate and effective support of the central circulation. Cardiocerebral resuscitation consists of continuous chest compressions—without mouth-to-mouth ventilations—administered by bystanders, and a new algorithm for emergency medical services that consists of sets of 200 chest compressions before and immediately after electrocardiographic analysis and, if indicated, a single shock. Ventilation is initially provided by passive oxygen insufflation rather than with intubation or bag-mask ventilation. Early establishment of intravenous or intraosseous access for epinephrine is emphasized. Postresuscitation care for comatose patients includes early coronary intervention and 24 hours of mild hypothermia. Studies show marked improvement in prehospital cardiac arrest patients with return of spontaneous circulation who subsequently received specialized postresuscitation care.*

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Key words: CPR • Cardiac arrest • Ventricular fibrillation • Cardiocerebral resuscitation • Passive oxygen insufflation • Hypothermia

In most areas of the world, the survival of patients with out-of-hospital cardiac arrest in the absence of early defibrillation has been disappointingly poor and has not improved[1] despite recommendations set forth in the Standards for Cardiopulmonary Resuscitation (CPR) and Emergency Cardiac Care (ECC), first published in 1974,[2] and subsequent standards and guidelines. This article will describe cardiocerebral resuscitation (CCR), an approach to resuscitation that stresses immediate and effective support of the central circulation.

Cardiopulmonary Resuscitation

CPR has not been effective for several reasons. One is because it has been advocated for 2 entirely different pathophysiologic conditions: primary cardiac arrest and respiratory arrest. In primary cardiac arrest, the pulmonary veins, left heart, and entire arterial system are filled with blood that is fully oxygenated at the onset of the arrest and remains so until resuscitation efforts begin to normalize tissue perfusion. In respiratory arrest, initially normal cardiac output, in the face of inadequate ventilation, deteriorates into severe arterial desaturation, hypotension, and, finally, secondary cardiac arrest. The rationale for advocating the same approach for these 2 disparate conditions was that it was thought imprudent to require lay individuals to distinguish between a respiratory arrest and a cardiac arrest. This mindset is no longer tenable. We must begin teaching this distinction because entirely different approaches are needed to improve survival of patients with primary cardiac arrest.

A second major reason why CPR has not been successful for primary cardiac arrest is that during resuscitation efforts, the forward blood flow is so marginal that interruption of chest compressions for any reason markedly reduces blood flow to the brain and thereby decreases the chance for survival. Chest compressions are interrupted—or not started—for a myriad of reasons. A major problem is that bystanders may not begin chest compression at all. In addition, a single rescuer may stop compressions for long periods of time to deliver mouth-to-mouth (MTM) ventilations. Emergency medical service personnel interrupt chest compressions for intubation, while checking pulse and rhythm, and for repeated defibrillator analysis.

A third major reason is that cardiac arrest and resuscitation efforts—either via "rescue breathing," intubation, or a bag valve mask—result in positive pressure ventilations. Positive pressure ventilations increase the intrathoracic pressure, thereby decreasing venous return to the chest and subsequent forward blood flow. A fourth reason is that delivering defibrillating shocks to the fibrillating heart after the electrical phase of untreated ventricular fibrillation (VF), when the heart has used up its energy stores, results in asystole or pulseless electrical activity—not a perfusing rhythm.

Cardiocerebral Resuscitation

Decades of research to solve these problems by my colleagues and me have led to the development of CCR, a new approach to patients with primary cardiac arrest.[3] CCR has been shown to dramatically improve survival of patients with witnessed out-of-hospital cardiac arrest (OHCA) and a shockable rhythm (Figure 1).[4,5] CCR for primary cardiac arrest consists of 3 major components: continuous chest compression (CCC) resuscitation for bystanders; a new approach to advanced cardiac life support (ACLS); and, recently added, postresuscitation care that includes early catheterization and hypothermia for resuscitated but comatose patients. Thus, a new "Chain of Survival" is established (Figure 2).

Bystander Resuscitation

It is well established that one of the major determinants of survival of patients with OHCA is whether they receive bystander CPR. If early bystander CPR is provided, the chance for survival improves. For years, my colleagues and I have advocated chest-compression-only, also called *CCC resuscitation*, for bystanders of witnessed (seen or heard) unexpected collapse in an individual who is not responsive (cardiac arrest).[6] This recommendation was based in part on our survey indicating that lay individuals were 4 times more likely to perform "bystander CPR" on strangers if MTM ventilations were not required (ie, if all that was required was CCC CPR).[7] The recommendation for CCC for bystanders was also based on our resuscitation laboratory findings. In our realistic nonparalyzed porcine model of OHCA, we found in several different studies that survival was the same with bystander-simulated CCC as with the approach then recommended

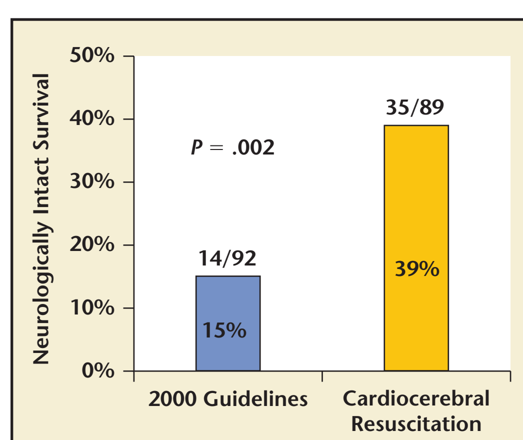

Figure 1. *Comparison of neurologically intact survival at 3 years in patients who were treated according to the 2000 Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiac Care and patients who were treated according to the principles of cardiocerebral resuscitation. Data from Kellum MJ et al.*[5]

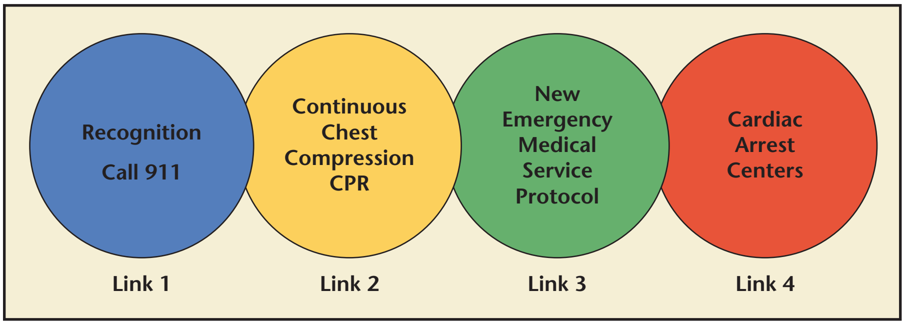

Figure 2. *Chain of survival for patients with cardiac arrest. CPR, cardiopulmonary resuscitation.*

by guidelines of 2 ventilations before each set of 15 chest compressions.[8-11] It is important to emphasize that in these early experiments, the 2 ventilations interrupted chest compressions for only 4 seconds, following the guideline-recommended 2 ventilations of 2 seconds each, before each set of 15 chest compressions.

We were disappointed when the 2000 guidelines recommended CCC CPR only for bystanders who were unable or unwilling to perform MTM ventilations.[12] Even with this caveat, CCC CPR was rarely taught or encouraged.

After the 2000 guidelines were published, it was found that rescuers who were recently certified in basic CPR interrupted chest compressions an average of 16 seconds to deliver the 2 MTM ventilations.[13] When we returned to our realistic porcine model of OHCA, we found that in patients who were treated with a 2:15 ratio of ventilations to compressions, in which the chest compressions were interrupted for a realistic 16 seconds, rather than the previous 4 seconds, to deliver the simulated MTM ventilations, the 24-hour neurologically normal survival was dramatically better with CCC than with 15:2 CPR.[11]

Based on these observations for bystander CPR—and on other findings that will be highlighted below for ACLS—in 2003, my colleagues and I concluded that we could not continue to follow the 2000 American Heart Association (AHA) guidelines and the International Committee on Cardiac Resuscitation (ILCOR) Guidelines for CPR and ECC and instead instituted the CCR approach.[3,14] We hoped that the 2005 guidelines would endorse CCC CPR, but they did not. Based on consensus and not on scientific evidence, the 2005 guidelines committee changed the recommendations for bystander resuscitation for cardiac arrest from 2:15 to 30:2.[15] We subsequently found in our nonparalyzed porcine model of OHCA that 24-hour neurologically normal survival was better with CCC CPR than with 30:2 CPR when the 30 chest compressions were interrupted for a realistic 16 seconds for a single rescuer to deliver the simulated MTM ventilations.[16]

Several surveys in humans have found that survival of patients with OHCA who received bystander CCC was as good as those who received so-called “rescue breathing” before each set of 15 chest compressions. These reports are of interest because in no circumstances was CCC formally advocated; bystanders wanted to do something, but they did not want to perform MTM-assisted ventilation. The largest of these studies was from Tokyo and was called the SOS-KANTO study.[17] Emergency medical services (EMS) personnel documented the type of CPR bystanders were performing when they arrived at the scene. Of the nearly 10,000 OHCA cases they found, about 40% had been witnessed. Of the almost 6000 witnessed cardiac arrests, 1324 of patients (about 30%) were receiving bystander CPR.[17] Chest compressions and MTM ventilations were being given to 712 patients, but 439 patients were receiving chest-compression-only bystander CPR.[17] The authors found that chest-compression-only was more likely to be performed by individuals who were not certified in basic CPR. The 30-day neurologically normal survival was 2.2% in those who did not receive bystander CPR, 4.2% in those who received chest compression and MTM ventilations, and 6.2% in those who received chest-compression-only.[17]

In any study of patients with out-of-hospital cardiac arrest, the survival is so poor that it is difficult to tell if an intervention is helpful, unless one looks at the subset of patients who had some chance of survival: those with witnessed arrest and a shockable rhythm on arrival of the EMS personnel. In a subgroup of these patients in the SOS-KANTO study, survival was 11% in patients receiving MTM plus chest compressions and 19% in patients who received chest-compressions-alone bystander CPR. It is notable that a technique that has not been advocated or taught is at least as effective, or perhaps even more so, as the 2:15 CPR approach that has been widely advocated and taught, with investment of millions of dollars and millions of hours, over the past few decades.

In April 2008, the AHA endorsed “hands-only CPR.”[18] The American Red Cross was quick to follow suit with “compression-only CPR.” Although the names are different, CCC CPR, hands-only CPR, and compression-only CPR are the same.

Although these recommendations are a giant step forward, in our opinion they do not go far enough. Hands-only CPR is recommended by the AHA for non-CPR certified individuals. For certified individuals who think they can perform the 2 MTM ventilations "quickly," the 30:2 ratio is still recommended.[18] My colleagues and I disagree with this recommendation, for we have shown that young, motivated medical students, recently AHA-certified in Basic Cardiac Life Support, interrupted chest compression for an average of 14 seconds, and that paramedics, the professionals, interrupted chest compression for an average of 10 seconds to perform the recommended 2 quick MTM breaths.[19,20] No one can give the 2 recommended breaths without interrupting chest compressions for a significant length of time.

Barriers to Initiation of Bystander Resuscitation Efforts

Although reluctance to perform MTM resuscitation has been proposed as the major reason why bystanders do not perform resuscitation, it is only one of the major reasons. Other reasons include fear of doing harm, fear of legal consequences, fear of not performing it properly, and being physically unable. All of these concerns must be addressed in our efforts to increase the prevalence of bystanders performing resuscitation efforts.

Interruption of Chest Compressions

Why are interruptions of chest compressions during resuscitation for cardiac arrest so harmful? During resuscitation efforts for cardiac arrest, the subject's forward blood flow is so marginal that stopping for any reason immediately stops blood flow to the brain. This point was forcefully brought to mind as I listened to an EMS dispatch recording of a woman who was receiving phone-directed instructions on how to perform bystander CPR. After a while, she returned to the phone and asked, "Why is it every time I press on his chest, he opens his eyes, and every time I stop to breathe for him, he goes back to sleep?" In other words, the woman was asking why every time she pressed on the patient's chest, he awoke from his coma, but every time she stopped chest compressions, he went back into his coma!

Positive Pressure Ventilations

Even if 2 rescuers are on the scene, the second individual should not provide so-called "rescue breathing" during cardiac arrest because MTM positive pressure ventilation during cardiac arrest is harmful for several reasons (Table 1). This new concept is extremely important, not only for bystander resuscitation efforts, but also, as will be emphasized below, for ACLS as well. As noted, during cardiac arrest and resuscitation efforts, the forward blood flow is so marginal that interruption of chest compressions for any reason decreases cerebral blood flow. Normally, each time we take a breath, it decreases intrathoracic pressure and enhances venous return to the heart. During cardiac arrest and resuscitation efforts,

Table 1
Advantages of CCC Resuscitation for Cardiac Arrest

- Early bystander-initiated resuscitation efforts are critically important to survival
- Bystanders are more willing to initiate bystander resuscitation with CCC because MTM ventilation is not required
- Early MTM ventilation is not necessary because the arterial blood is fully oxygenated at the onset of cardiac arrest
- MTM ventilation, or so-called *rescue breathing*, is deleterious because it results in prolonged (16 seconds) interruptions of critical chest compressions during resuscitation efforts administered by a single rescuer
- "Rescue breathing" increases the intrathoracic pressure, decreasing venous return to the chest and subsequent blood flow to the heart and brain. Therefore, even if a second person is available, he or she should not perform MTM breathing, but should alternate with the first person in administering chest compressions because CCC CPR is tiring
- MTM ventilation during resuscitation efforts increases gastric distension and vomiting. The reported incidence is 50%
- Gasping occurs in about 50% of patients soon after cardiac arrest and, if present, will continue. Gasping provides physiological ventilation with decreased intrathoracic pressures, which increases venous return and subsequent blood flow to the heart and brain
- Gasping, if recently stopped, is more likely to resume or, if not present, to start with CCC resuscitation
- Partial upper airway obstruction may not be all bad; should it occur with gasping efforts, it will have the same effect as an "inspiratory impedance valve"
- CCC is easier to teach and to learn than cardiopulmonary resuscitation

CCC, continuous chest compression; MTM, mouth-to-mouth; CPR, cardiopulmonary resuscitation.

positive pressure ventilations increase intrathoracic pressure, decreasing venous return to the chest, and, as a result, decreasing subsequent blood flow to the heart and brain.[21,22]

The Importance of Gasping During Cardiac Arrest

Early bystander-initiated CPR necessitates that the cardiac arrest be promptly recognized. The early recognition of cardiac arrest is not easy. Witnessed (seen or heard), unexpected collapse in an individual who is unresponsive should be considered a primary cardiac arrest, irrespective of age. We have documented in our porcine model of OHCA that following the induction of VF, what appears to be normal breathing continues for about a minute. Then, a significant number of these swine gasp for the next few minutes of untreated VF. Gasping is not universal in this porcine model of OHCA, but neither is it in humans.

However, we have recently confirmed observations made by Clark and colleagues[23] and Bång and coworkers[24] almost 2 decades ago, who found that gasping, variously described as snoring, snorting, gurgling, or moaning or as agonal, barely, labored, noisy, or heavy breathing, is common following cardiac arrest.[25] Clark and colleagues[23] reviewed taped recordings from dispatch centers and reported agonal respiration or gasping activity in 55% of 445 out-of-hospital patients with a witnessed (seen or heard) arrest. In our analysis of 1218 EMS-attended witnessed OHCAs, gasping was present in 33% of patients who arrested after EMS arrival, in 20% when EMS arrival was within 7 minutes, in 14% when EMS arrival time was from 7 to 9 minutes, and in 7% when EMS arrival time was longer than 9 minutes.[25]

Gasping is important in patients with cardiac arrest for several reasons. It indicates marginal but adequate blood flow to the brain. In our observations in humans, survival to hospital discharge occurred in 28% of patients who had gasped and in only 8% of patients who had not gasped. Although bystander chest compressions increase the frequency of gasping, gasping itself appears to be an independent predictor of survival. Among the 481 patients who received bystander CPR, survival to hospital discharge occurred among 39% of patients who had gasped versus only 9% of patients who had not gasped.[25]

In our swine studies, CCC resuscitation was more likely to be associated with continuation of or recurrence of gasping and a favorable neurologic outcome as compared with resuscitation efforts with 30:2, when the chest compressions were interrupted a realistic 16 seconds to deliver the 2 simulated "rescue breaths."

From a hemodynamic point of view, gasping is beneficial during cardiac arrest because it oxygenates the blood in a physiologic manner by decreasing intrathoracic pressures and thereby increasing venous return to the chest and enhancing forward blood flow to the brain during chest compressions. Gasping is often not recognized as a sign of cardiac arrest, which delays prompt initiation of resuscitation efforts. Furthermore, during resuscitation efforts, the return of gasping is likely to be interpreted as a sign of recovery, so resuscitation efforts are often interrupted. Gasping is not a sign of recovery but a sign that resuscitation efforts are effective and should be continued. The chance of survival in patients who gasp is greater. This fact needs wider recognition so that resuscitation efforts in such patients are not interrupted or discontinued. When gasping is present, the need for assisted ventilation during resuscitation efforts does not appear to be necessary.

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The New ACLS of Cardiocerebral Resuscitation

The protocol for the ACLS portion of CCR is outlined in Figure 3. From its inception, the CCR approach prohibited early endotracheal intubation because of the inordinate delays in chest compressions.[3] Beginning in 2004, positive pressure ventilations were prohibited in any form for the same reasons that MTM ventilations by bystanders are prohibited (Table 1). Instead, CCR encourages an oral pharyngeal airway, a nonrebreather mask, and high-flow oxygen (10 to 15 L/min).[4,5] This approach is called *passive oxygen insufflation* (POI).

POI was initially instituted as part of CCR because of the problem of hyperventilation. More than 10 years ago, my colleagues and I[26] reported that during in-hospital resuscitation efforts for cardiac arrest, the average rate of bag ventilations was 37 per minute. At that time, we did not think that ventilations were harmful. Several years later, Aufderheide and colleagues[22] observed that ventilation rates during attempted resuscitations by paramedics averaged 37 per minute—an incredible coincidence. It was obvious that during the excitement of attempting resuscitation from cardiac arrest, hyperventilation was common.

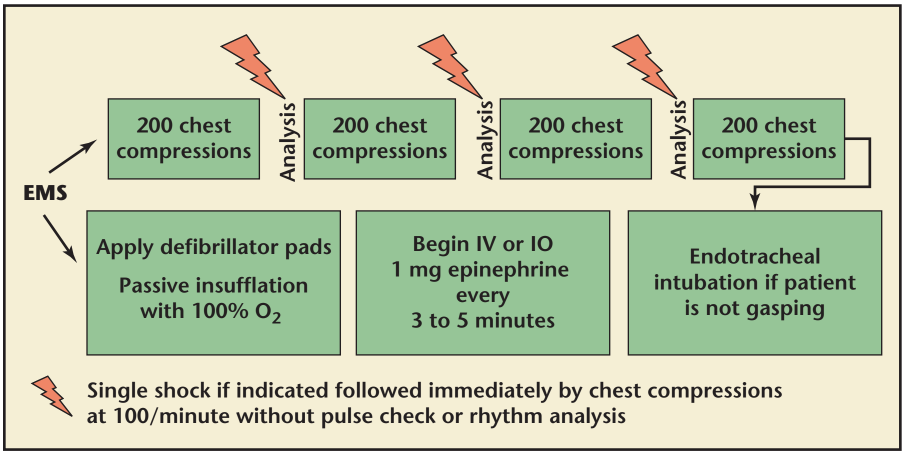

Figure 3. *Cardiocerebral resuscitation protocol for emergency medical services personnel who arrive at the side of a patient with suspected cardiac arrest. EMS, emergency medical services; IV, intravenous; IO, intraosseous.*

The deleterious effect of positive pressure ventilations during cardiac arrest began to be appreciated (Table 1). Aufderheide and associates[21] discussed the fact that during resuscitation efforts for cardiac arrest, the forward blood flow is so poor that increasing intrathoracic pressure by positive pressure ventilation decreases venous return to the chest, and the subsequent decrease in cardiac output to the heart and brain was deleterious. The adverse effects of hyperventilation were emphasized in their editorial, "Death by Hyperventilation."[21]

To counteract the fact that positive pressure ventilation during cardiac arrest is deleterious during resuscitation efforts, Lurie and colleagues[27] developed the ResQPOD® (Advanced Circulatory Systems, Inc, Eden Prairie, MN), which negates some of the adverse effects of positive pressure ventilations during resuscitation. We think the same goal can be accomplished with passive oxygen insufflation.

Emergency medical systems that instituted only the ACLS portion of CCR have seen a dramatic improvement in the survival of patients with witnessed OHCA and a shockable rhythm. In Rock and Walworth counties of Wisconsin, neurologically normal survival of patients with witnessed cardiac arrest and a shockable rhythm on arrival of EMS personnel increased from 15% under the 2000 CPR and EMS guidelines to 38% under the CCR approach.[5]

In Arizona, minimally interrupted cardiac resuscitation, which permits ventilation either by positive pressure ventilation (bag mask) or POI, also resulted in a significant increase in survival, from 5% to 18%.[28] However, recent subanalysis of these data revealed that the survival to hospital discharge of the subset of patients who received POI and, thus, true CCR, was 38%, the same rate reported from the Wisconsin counties where POI was used.[5]

Three-Phase Time-Sensitive Model of Untreated VF

Some of the rationale of CCR can be best explained by the 3-phase time-sensitive model of untreated VF articulated by Weisfeldt and Becker.[29] Their editorial emphasized that during the first 4 minutes or so of untreated VF (the electrical phase of untreated VF), the most important intervention is prompt defibrillation.[29] This is why implanted cardioverter defibrillators and automated external defibrillators are so effective when used early in VF arrest. However, after about 4 minutes of continued VF without perfusion, the heart depletes its energy stores. When shocked in this "circulatory phase" of untreated VF, the resulting rhythm is usually either asystole or pulseless electrical activity. Fortunately, this electrical phase can be prolonged by perfusion of the heart. During cardiac arrest, this is accomplished by uninterrupted chest compressions.

After the electrical phase, during the so-called *circulatory phase* of untreated VF arrest, it is essential to perfuse the heart by chest compressions to generate an adequate coronary perfusion pressure prior to defibrillation.[29] This circulatory phase of untreated VF lasts for an uncertain period of time and is followed by the metabolic phase, during which current approaches to therapy are usually not successful.

The ACLS Portion of Cardiocerebral Resuscitation

If a cardiac arrest occurs after EMS arrival during the electrical phase of VF arrest, the therapy of choice is prompt defibrillation. However, most EMS ambulances do not arrive during the electrical phase but during the circulatory phase of untreated VF arrest, where perfusion of the fibrillating heart is necessary prior to defibrillation. Accordingly, in CCR, the task of the first EMS responder is to begin 200 forceful chest compressions at 100 compressions a minute with full release, which is the heel of the hand coming off of the chest after each compression (Figure 3). The second EMS responder applies the defibrillator pads, activates the defibrillator, and institutes POI. He or she then relieves the person doing the chest compressions, as forceful compressions at 100 compressions per minute with full release after each compression is tiring. The caregiver relieved from performing chest compressions obtains intravenous or intraosseous access and administers epinephrine. Paramedics continue to trade off performance of chest compressions, ideally after each set of 100 chest compressions. A metronome set at 100/min is recommended.

As noted above, gasping is an indication of marginal but adequate cerebral perfusion, as patients who are gasping at the time of defibrillation are more likely to survive neurologically intact. If the patient begins or continues to gasp with chest compressions, POI is continued. Intubation is indicated if the patient does not gasp while receiving 3 series of 200 chest compressions, including analysis with or without shock, and then 200 more chest compressions (Figure 3). However, if the patient is gasping, the resuscitation procedures are continued. If the patient is intubated or being ventilated by bag mask or bag valve mask, it is difficult to tell if he or she is gasping, and these devices interfere with the beneficial effects of gasping.

Comparison of Cardiocerebral Resuscitation With Guidelines for ACLS

The 2000 guidelines, and previous ones, not only recommended early endotracheal intubation (which delays or interrupts chest compressions an inordinate duration during the circulatory phase of VF cardiac arrest) and positive pressure ventilations (which increase intrathoracic pressures, thus decreasing venous return to the chest and, subsequently, arterial perfusion of the brain), but also recommended up to 3 sequential defibrillator shocks for VF arrest. Because EMS services rarely arrive during the so-called "electrical phase" of VF arrest, these delays for endotracheal intubation and subsequent interruption or delay of chest compressions are not beneficial.

Following the 2000 guidelines, paramedics were compressing the chest of their patients only about half the time.[30,31] A mantra of CCR is that the compressions are the patient's heart beat—every time chest compression is discontinued, for any reason, blood flow to the brain stops.

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Fortunately, the 2005 guidelines incorporated some of the features of CCR, most notably single shocks rather than stacked shocks. The guidelines recommend 5 cycles of 30:2 chest compressions to ventilations immediately after the first shock before rhythm and pulse analysis.[32] They also recommend that intubation be delayed, but still advocate positive pressure ventilation. Chest compressions prior to initial shock are optional in the 2005 guidelines, but when given should be done so in 5 cycles of 30:2 compressions to ventilations prior to the shock.

As noted above, in April 2008, the AHA recommended that uncertified individuals perform "hands-only CPR" in adults.[18] For the reasons discussed, my colleagues and I recommend that CCC resuscitation be performed by all bystanders. We also recommend CCC resuscitation by bystanders for cardiac arrest, regardless of the patient's age. A teenager can have cardiac arrest due to a variety of cardiovascular abnormalities, including long QT syndromes, abnormal origin of a coronary artery, and hypertrophic or inherited cardiomyopathy. If a child is hit in the chest with an object and develops ventricular fibrillation, that is a cardiac arrest and should be treated as such and not as a respiratory arrest. Again, an unexpected, witnessed collapse of a person who is not responsive should be considered a primary cardiac arrest, and the chain of survival should be initiated.

Cardiac Arrest Centers

Previously, many patients who achieved return of spontaneous circulation but were comatose had care actively withdrawn. Large, randomized, controlled trials and meta-analyses have shown significant improvement in survival and necrologic outcome among resuscitated but comatose patients who experienced witnessed prehospital VF and who received therapeutic hypothermia. There is evidence that even more aggressive postresuscitation interventions may significantly improve outcome. In addition to therapeutic hypothermia, these interventions include optimization of hemodynamics, blood glucose, acid-base status, and electrolytes, along with anticonvulsant therapy, antiarrhythmic therapy, early cardiac catheterization, and appropriate percutaneous coronary interventions. Sunde and associates[33] reported marked improvement in prehospital cardiac arrest patients with return of spontaneous circulation who subsequently received specialized postresuscitation care. In their study, favorable neurologic survival occurred in 56% of patients during the intervention period compared with only 26% during the control period. My colleague

Karl B. Kern, MD, has advocated a more aggressive approach to catheterization in these patients, as he has observed patients without ST-segment elevation postresuscitation to have acute total occlusion in a coronary artery (personal communication).

Bobrow and associates[34] have instituted the concept of cardiac arrest centers, much like trauma centers, throughout the state of Arizona. His group has shown that longer prehospital transport intervals had no adverse effect on patient outcome. This finding has significant implications for regionalization of postresuscitation care.[35]

In-Hospital Cardiac Arrest

Although this article's focus has been on OHCA, these concepts apply to in-hospital primary cardiac arrest as well. Only about one-quarter of in-hospital cardiac arrests are due to ventricular fibrillation, and not all of these cases are primary cardiac arrests. However, unexpected collapse in nonresponsive patients should be considered a primary cardiac arrest and treated according to the principles outlined here. It will take a paradigm shift in the thinking of most physicians, but this shift is necessary if we are to significantly improve survival of patients with primary cardiac arrest, be they in or out of the hospital. ■

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Main Points

- Cardiocerebral resuscitation (CCR) has been shown to dramatically improve survival of patients with witnessed out-of-hospital cardiac arrest and a shockable rhythm.
- CCR for primary cardiac arrest consists of 3 major components: continuous chest compression resuscitation for bystanders, a new approach to advanced cardiac life support, and postresuscitation care that includes early catheterization and hypothermia for resuscitated but comatose patients.
- Bystanders are 4 times more likely to perform cardiopulmonary resuscitation on strangers if mouth-to-mouth ventilations are not required.
- During resuscitation efforts for cardiac arrest, the subject's forward blood flow is so marginal that discontinuation of compressions for any reason immediately stops blood flow to the brain.
- During cardiac arrest and resuscitation efforts, positive pressure ventilations increase intrathoracic pressure, decreasing venous return to the chest, and, as a result, decreasing subsequent blood flow to the heart and brain.
- Gasping is common following cardiac arrest, and it appears to be an independent predictor of survival.

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