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Cardiac arrest: clinical management**

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**Introduction**

Although detailed algorithms and consensus guidelines exist for management of cardiac arrest, often referred to as Basic Life Support (BLS) and Advanced Cardiac Life Support (ACLS), there are unique practical and scientific considerations that may affect the execution of resuscitation efforts in the out-of-hospital setting. EMS medical directors and field personnel including EMS physicians must be aware of these factors when developing protocols for prehospital resuscitation. They must also understand the scientific basis for and the controversies surrounding recommended resuscitation actions.

This chapter reviews scientific and practical considerations for carrying out BLS and ACLS in the prehospital setting. For specific treatment algorithms, the reader is referred to the American Heart Association (AHA) Emergency Cardiac Care (ECC) guidelines [1].

**Specific interventions**

**Chest compressions**

Chest compressions are essential in cardiac arrest resuscitation. Paradis demonstrated that only chest compressions generate coronary perfusion pressure (CPP) and that a CPP of at least 20 mmHg is important for achieving return of spontaneous circulation (ROSC) [2]. Multiple studies highlight the role of early chest compressions in survival from cardiac arrest [3–6].

The most recent BLS and ACLS guidelines emphasize the delivery of continuous chest compressions with as few interruptions as possible [1]. Kern et al. demonstrated that several consecutive chest compressions are necessary to generate adequate CPP [7]. CPP drops off immediately when chest compressions are discontinued [8]. The proportion of resuscitation time without chest compressions, termed *hands-off time* or *no-flow fraction,* is inversely associated with cardiac arrest survival [9]. Compression depth, rate, and full recoil are also critical characteristics for effectiveness.

Prior work highlighted the often substandard CPR performed by prehospital and in-hospital providers. In a series of prehospital cardiac arrests in Europe, Wik et al. showed that chest compressions were delivered on average only half of the time while the patient was in arrest and that most compressions were too shallow [10]. Abella et al. found similar observations in an in-hospital series [11].

Delivering chest compressions during cardiac arrest resuscitation poses practical challenges. The treating EMS team must provide continuous chest compressions with as few interruptions as possible and must ensure high-quality chest compressions with adequate depth, rate, and recoil. To achieve these chest compression goals, additional rescuers should be dispatched to provide assistance at cardiac arrests. Team members providing chest compressions should rotate frequently, ideally every 1–2 minutes [1].

Several cardiac monitors use a compression paddle or other technology to measure the depth and rate of chest compressions [10,11]. These monitors are able to provide real-time audio and/or visual feedback, indicating to the rescuer whether or not to increase the depth or rate of compressions. Preliminary data suggest improved clinical chest compression performance through the use of feedback systems [12].

Various mechanical devices for automating chest compressions are now available. The Thumper (Michigan Instruments, Grand Rapids, MI) has been used for approximately 40 years and provides chest compressions using a pneumatic piston [13]. The Autopulse Resuscitation System (Zoll Corporation, Chelmsford, MA) facilitates chest compressions using a circumferential load-distributing band [14,15]. The Lund University Cardiopulmonary Assist Device (LUCAS) (Lund, Sweden) provides active compression and decompression through a pneumatic piston attached to a suction cup on the chest [16]. Use of mechanical compression devices is fairly widespread in Europe and is growing in the United States.

The scientific data evaluating the effectiveness of these devices remain inconclusive. One urban EMS agency evaluated the Autopulse in a before/after fashion and found increases in both ROSC and survival [14]. However, a larger, multicenter, randomized controlled trial demonstrated worsened outcomes with the intervention [15]. The authors attributed this observation to potential delays in CPR required to place and activate the device. The LUCAS device was effective in a small study of 100 patients, but its benefit was only noted in those who received it within 15 minutes from the ambulance call [16]. Additional innovations and trials are sure to follow. It is important to note that each device requires time to place on the patient, during which no compressions occur. Any protocol that incorporates the use of mechanical devices must stress the importance of continuing manual compressions as much as possible until the device starts; some experts suggest withholding use of mechanical devices during the initial resuscitation effort.

**Defibrillation**

Defibrillation of ventricular fibrillation or ventricular tachycardia (VF/VT) is the most effective intervention for resuscitation from cardiac arrest. Ideally, automated external defibrillators (AEDs) are present at the site of the arrest for use by willing trained or untrained bystanders, perhaps at the prompting of the 9-1-1 call-taker. All medical first responders and BLS providers, including all BLS ambulances, should be equipped with AEDs. Most ALS personnel deliver shocks by manually operating a cardiac monitor-defibrillator after determining the patient has a shockable rhythm. Although many devices are configured with both hand-held paddles and cables for “hands-off” self-adhesive pads, use of the pads is believed to be safer, particularly in the uncontrolled field setting.

An important technical consideration is the type of electrical waveform delivered by the defibrillator [17]. Older defibrillators use monophasic electrical current. In this mode, the device delivers electrical current in a single direction only. To compensate for increased impedance (electrical resistance), older protocols specified escalating energy levels for each successive rescue shock. Now that shocks are given one at a time, each shock should be at maximum energy output, typically 360 J. Although most current defibrillators are biphasic, some EMS systems may still use monophasic defibrillators.

In a biphasic defibrillator, electrical current flows first in one direction, then in the opposite direction. This modality theoretically purges excess electrical charge from the heart. Biphasic defibrillators measure the impedance across the chest and adjust the voltage and/or duration of current appropriately. Different models also alter the pattern of delivered current, most often using a rectilinear or truncated exponential waveform. Compared with monophasic defibrillators, biphasic defibrillators demonstrate higher rescue shock success at lower energy levels and have been associated with increased rates of ROSC [18].

Energy levels for biphasic defibrillators should be based on manufacturer recommendations because each model has different waveform and delivery characteristics that affect shock efficacy. Although some manufacturers endorse non-escalating low-energy shocks (150 J), recent data suggest that higher energy biphasic shocks may increase rescue shock success without impairing cardiac function [19].

Another consideration is the interface between BLS and ALS defibrillation equipment. Some AEDs can be converted to manual mode by ALS personnel. This feature is an important logistical consideration because switching from the BLS AED to the ALS defibrillator may incur delays. Some brands use the same defibrillation pads on BLS and ALS models, allowing providers to simply unplug the connector from one device and plug into the other. The EMS physician should be aware that the AED “analyze and shock” algorithm may add 49–59 seconds of hands-off time [20]. This is an important consideration when ALS rescuers care for a patient with an AED attached. One method of minimizing hands-off time is to continue chest compressions until just before defibrillation. Recent data have suggested that continuing chest compressions during defibrillation may be feasible [21]. Others have demonstrated that standard examination gloves may be insufficient protection from electrical shock during external defibrillation [22]. Balancing safety and minimizing hands-off time remains an active area of research.

A current scientific controversy is whether initial defibrillation should precede or follow an initial course of chest compressions. Prior AHA ECC algorithms specified rescue shocks first for VF, regardless of arrest duration [23]. However, several factors support performing initial chest compressions before rescue shocks, including the prolonged duration of most out-of-hospital arrests before treatment is initiated, which leads to the depletion of myocardial high-energy phosphates, cellular damage resulting from accumulated free radicals, and the development of severe acidosis [24,25]. Theoretically, a period of chest compressions may perfuse the heart and reduce the severity of these anomalies, better preparing the heart for defibrillation.

However, a recent randomized clinical trial between chest compressions before rhythm analysis and immediate rhythm analysis showed no difference in the rate of good neurological outcome between groups (19.4% in early analysis versus 18.5% in chest compressions before analysis cohorts) [26]. Two clinical studies have demonstrated improved outcomes in prolonged (>4 minutes) VF arrests when chest compressions were delivered before defibrillation [27,28]. Current ACLS guidelines recommend immediate defibrillation in witnessed arrests but delivering chest compressions for about 2 minutes before rhythm analysis in unwitnessed arrests [1].

**Airway management**

For many years airway management received emphasis in cardiac arrest care, and ALS rescuers placed high priority on endotracheal intubation (ETI) of cardiac arrest patients. However, the results of several studies question the wisdom of intubation during out-of-hospital cardiac arrest resuscitation. Some of the adverse events noted were tube misplacement, tube dislodgment, multiple laryngoscopy efforts, and failed ETI efforts [29–32]. Aufderheide et al. found that inadvertent hyperventilation often occurs after ETI, raising intrathoracic pressure and compromising CPP [33]. Perhaps most important is the frequent and often prolonged interruption of chest compressions [34].

The application of these findings to EMS practice poses important challenges. Although bag-valve-mask ventilation is theoretically adequate for resuscitation, the technique is difficult to execute in the prehospital setting, in which providers may need to deliver ventilations with the patient situated on the floor, in the back of a moving ambulance, or on a moving stretcher [35]. Most EMS agencies still perform ETI for cardiac arrest, but many try to limit the number and duration of ETI attempts [32]. Capnography should be used to verify endotracheal tube placement [36]. Although dependent on the quality of chest compressions, capnography waveforms in low-flow states are still useful for ensuring endotracheal tube position.

Another emerging approach to cardiac arrest airway management is to use supraglottic airways (such as the King LT®) instead of ETI. These devices are inserted blindly into the airway without the need for direct laryngoscopy, and can typically be placed very quickly without pausing compressions (see Volume 1, [Chapter 3](https://jigsaw.vitalsource.com/books/9781118990827/epub/OPS/c03.xhtml)). Several EMS agencies have chosen this approach, reasoning that they cannot perform traditional ETI without compromising chest compressions [37]. Retrospective studies have conflicting results. In a review of out-of-hospital cardiac arrests in Japan between 2005 and 2008, there was no difference in the rate of good neurological outcome in patients receiving endotracheal intubation rather than supraglottic airways (odds ratio (OR) 0.71; 95% confidence interval (CI) 0.39, 1.30) [38]. A subanalysis of the ROC PRIMED trial demonstrated a higher rate of survival with good functional status in patients receiving endotracheal intubation rather than supraglottic airway placement (OR 1.40; 95% CI 1.04, 1.89) during the resuscitation [37].

**Ventilation**

Another important consideration is the role of ventilation during chest compressions. Recent data question the need for ventilation with bystander CPR in patients with short-duration VF [7,39–43]. The theoretical bases for this approach include:

* the distractions posed by multiple interventions
* the subsequent reduction in number of chest compressions
* the adverse effect of hyperventilation on CPP
* bystander reluctance to perform mouth-to-mouth ventilation [33, 44–46].

Although “no ventilation” has practical value for bystander care, it is not clear how or if these principles should be applied to EMS care. There is some evidence that prearrival instruction for compression-only CPR by dispatchers results in delivery of earlier and more chest compressions, but not an increase in survival [47,48]. Some EMS systems have adopted protocols making active ventilation optional during the initial resuscitation, instead placing an oral airway and oxygen mask until sufficient rescuers are on scene. This allows the first-arriving crew to focus on compressions and defibrillation.

Considerable scientific data have highlighted the importance of controlled ventilation during resuscitation. Aufderheide et al. demonstrated in cardiac arrests that hyperventilation increases intrathoracic pressure, resulting in decreased preload and CPP [33]. They also showed that inadvertent hyperventilation occurs frequently during resuscitation efforts, despite specific training to avoid this phenomenon. Ventilation during cardiac arrest should consist of tidal volumes of 500–600 mL at a respiratory rate of 8–10 breaths/min.

The impedance threshold device (ITD) is a ventilation adjunct that may be attached to either a face mask or an endotracheal tube and contains a one-way valve that permits exhalation during the downstroke of chest compression but prevents passive inhalation during the upstroke of chest compression. As a result, the ITD generates increased negative intrathoracic pressure during chest recoil, increasing cardiac preload and CPP. While preclinical and small trial data were favorable, a large randomized trial of the ITD versus sham device yielded similar rates of survival with good neurological outcome between groups (ITD 5.8% versus sham device 6.0%; p=0.71) [49–54].

**Medications**

Although numerous medications may be used during treatment of cardiac arrest, the primary agents are vasopressors (e.g. epinephrine and vasopressin) and antiarrhythmics (e.g. lidocaine and amiodarone). ACLS algorithms provide specific guidelines for the use and doses of these agents [1].

No drug has demonstrated improved outcomes following cardiac arrest in humans [55–58]. The continued use of these drugs is based on tradition, theory, and animal research, and the selection of specific agents in each class is largely a matter of individual choice. EMS physicians must be aware that the only medications evaluated by randomized clinical trials are epinephrine, amiodarone, vasopressin, and magnesium [56,59,60]. Current ACLS guidelines downplay the use of these medications in favor of quality CPR performance [1].

Vasopressors serve two intended purposes in cardiac arrest: vasoconstriction, and exerting positive inotropy and chronotropy. Alpha-agonists increase peripheral resistance, shunting blood flow to the brain and heart. Beta-agonists increase inotropy and chronotropy. In the clinical context, these agents should help to sustain coronary and cerebral perfusion before restoration of pulses. AHA guidelines suggest administering 1 mg of IV epinephrine every 3–5 minutes and provide an option to substitute one dose with 40 units of vasopressin [1].

Compelling animal data indicate increased ROSC with the early delivery of epinephrine or vasopressin [61–64]. Although several small clinical series have reported increases in ROSC and survival to admission for patients treated with vasopressin, a randomized trial comparing vasopressin with epinephrine versus epinephrine alone did not demonstrate additional benefit from vasopressin use [59,65–67]. Two randomized controlled trials have shown no improvement in survival to discharge, but have shown increased rates of ROSC [68,69].

With the use of vasopressors, there is a trade-off between increased coronary perfusion and reduced cerebral perfusion (possibly via increased cerebral vasoconstriction). A once-popular ACLS approach was the use of high-dose epinephrine (5–7 mg IV) [55]. Although clinical trials using high-dose epinephrine demonstrated increased rates of ROSC, this did not translate into survival to discharge [55].

Antiarrhythmics are commonly used in cases of VT/VF cardiac arrest and may increase the likelihood of conversion to a perfusing rhythm. Lidocaine and amiodarone are currently recommended antiarrhythmics for shock-refractory VF; both have Class IIb recommendations (conflicting evidence) [1]. One randomized controlled trial of amiodarone demonstrated an increase in ROSC, but not improved survival to hospital discharge [60]. An important point for use in critical situations, especially with limited resources such as the out-of-hospital setting, is that amiodarone is logistically more difficult to administer than lidocaine, requiring the medication to be dispensed from glass vials. ACLS guidelines indicate that amiodarone has a stronger supporting evidence base than lidocaine, as there have been no studies evaluating lidocaine [1]. EMS physicians may choose between an IV bolus of 300 mg of amiodarone or 1–1.5 mg/kg of lidocaine for patients suffering pulseless VT/VF. A randomized, controlled trial evaluating amiodarone, lidocaine, and placebo is currently enrolling and might help to clarify this issue ([ClinicalTrials.gov](http://clinicaltrials.gov/), identifier NCT01401647).

Epidemiological studies suggest that pulseless electrical activity (PEA) and asystole are increasingly common in out-of-hospital cardiac arrests [70–73]. Atropine is a vagolytic and reverses cholinergic-mediated decreases in heart rate, blood pressure (BP), and vascular resistance [1]. Although traditionally it has been used in PEA or asystolic cardiac arrest, the limited available research does not suggest any benefit, and this drug is no longer recommended for routine use. Epinephrine should be administered, and potentially treatable causes (the 5 Hs and 5 Ts of ACLS) considered ([Box 12.1](https://jigsaw.vitalsource.com/books/9781118990827/epub/OPS/c12.xhtml#c12-fea-0001)).

**Box 12.1 The potentially treatable Hs and Ts of cardiac arrest**

**Hs:**

Hypovolemia

Hypoxia

Hyper-/hypokalemia

Hydrogen ion (acidosis)

Hypothermia

**Ts:**

Toxins

Tamponade (cardiac)

Tension pneumothorax

Thrombosis (coronary)

Thrombosis (massive pulmonary)

An additional drug worth comment is sodium bicarbonate. For years, sodium bicarbonate was administered routinely during cardiac arrest to reverse the metabolic acidosis of cardiac arrest, and hopefully increase the effectiveness of vasopressors and antiarrhythmics. In formal trials, this drug did not improve survival [74]. Sodium bicarbonate may be reasonable in scenarios of suspected hyperkalemic arrest (such as individuals with known renal failure) and in prolonged resuscitations with adequate ventilation. Calcium (chloride or gluconate), however, is the most effective medication in cases of severe hyperkalemia affecting cardiac conduction.

**Additional therapies**

Cardiac arrest represents the ultimate scenario of cardiovascular collapse. Consequently, cardiopulmonary bypass or extracorporeal life support (ECLS) may represent one potential solution. In tightly defined populations, ECLS combined with early angiography and hypothermia therapy has yielded good neurological outcomes in a significant proportion of patients [75–77]. In a study which used ECLS only after standard therapy failed, the rate of good neurological outcome was small [78]. Optimal selection of patients for this therapy will require early mobilization of resources given the association between prolonged arrest and poor neurological outcomes [79].

**Principles of management**

**Resuscitation protocols**

Cardiac arrest care interventions are time-critical. Thus, protocols should allow EMS personnel to initiate resuscitation immediately. Non-physician providers should provide initial cardiac arrest care using standing orders, as there is inadequate time to consult with the direct medical oversight physician for detailed guidance. The protocols should detail interventions for the various ECG rhythms likely to be encountered: VF, VT, PEA, and asystole. Protocols should provide convenient reference to medication dosages, mixtures, and administration rates. Other practical information should also be included, such as criteria for termination of resuscitation. Many systems use current AHA ACLS algorithms as the basis for cardiac arrest protocols [1].

Emergency medical services personnel should be encouraged to contact the direct medical oversight physician for additional direction after initial successful or unsuccessful resuscitative efforts, as well as for unusual or complicated situations. Due to the time-sensitive nature of cardiac arrest and the often chaotic resuscitation scene, radio or phone interactions with the EMS personnel must be short, directed, and relevant. The physician must understand that detailed medical history or preceding symptoms are usually not known and are largely (although not entirely) irrelevant to the acute resuscitation phase of the patient’s care. EMS personnel may seek medical oversight physician direction for more complex interventions and situations, such as initiating a dopamine infusion or external pacing. Direct medical oversight physicians must be prepared to provide adequate direction for these less common situations.

**High-performance CPR: the pit crew approach**

Based on the emerging concepts described above, an appreciation has developed for the importance of doing CPR in a very high-quality and precise manner and for providing the other components of resuscitation in a more timely and more measured way. Achieving these goals requires a team of providers working together in a carefully choreographed approach. Some have suggested that personnel at a cardiac arrest scene should function like a racing pit crew, each very skilled, with a specific task or tasks, and working in a synchronized manner.

This concept also emphasizes and includes practice sessions on high-quality performance: assuring continuous chest compressions with proper depth, rate, and recoil, changing compressors (quickly) every 100–200 compressions, and integrating defibrillation such as charging the defibrillator with 20 or so compressions left in the cycle so the operator can quickly assess the rhythm and push to shock as soon as the compressor is off the chest. The first two responders should position themselves on each side of the chest, and while one (EMS1) starts compressions, the other (EMS2) applies the defibrillation pads and turns on the monitor. As EMS1 finishes the first round of compressions, the rhythm is analyzed. If a shockable rhythm is found, EMS2 can defibrillate and then begin chest compressions. Meanwhile, EMS1 is relieved of compressing (for 1 minute), and he or she should insert an oral airway and place an O2 mask (or ventilate with a bag-valve-mask). When EMS2 is relieved for his or her minute break, he or she looks for IV or IO access and administers epinephrine (or vasopressin, based on system protocol as established by the medical director). The rhythm should be checked every 200 compressions or every 2 minutes. As more personnel arrive, attention can be paid to ventilation and placement of an advanced airway (endotracheal intubation or supraglottic airway). Finally the team leader should reassess all ongoing therapies, monitor function, and consider potentially treatable specific conditions.

Care during this initial 10–20 minutes of resuscitation should all occur at the location where the patient was found, or an area as close as possible. Efforts to “package the patient” or to begin to transfer the patient to the ambulance compromise all resuscitation efforts, not just the quality of chest compressions. Moving the patient to the ambulance or transporting immediately, except for some very rare situations, is not beneficial.

**Withholding resuscitation**

In the past, EMS personnel initiated resuscitative efforts regardless of the family’s or patient’s wishes or a written do not resuscitate (DNR) order. This practice was fueled by the belief that EMS personnel could follow only the orders of an EMS medical oversight physician, not those of an independent physician, such as the patient’s own primary care physician or oncologist. Also, EMS personnel feared medicolegal repercussions if they did not initiate resuscitation. Fortunately, current practices take a more progressive approach, recognizing the importance of patient autonomy, the futility of initiating or pursuing resuscitation in select cases, and the unwarranted risks of futile resuscitation.

The primary EMS situations involving non-initiation of resuscitation efforts include the following.

* The patient has a DNR order and should not receive resuscitative efforts.
* The patient has clear signs of irreversible death (such as rigor mortis) and should not receive resuscitative efforts.

Emergency medical services agencies should have protocols and policies reflecting these situations. Personnel should receive education in the ethical principle of patient autonomy and the local regulations regarding patient directives. In each situation, consultation with the direct medical oversight physician is appropriate.

**Do not resuscitate status**

Do not resuscitate is a specific physician order. This differs from living wills or advance directives that merely outline the patient’s general wishes regarding life-sustaining interventions. The most common EMS scenarios involving cardiac arrest patients with DNR orders include nursing home or assisted living facilities. Patients with known terminal conditions may also have DNR orders but may live in private residences or hospice facilities.

Bystanders or caregivers may summon 9-1-1 despite the presence of a DNR order. This may occur because of lack of knowledge of the patient’s status, uncertainty about the patient’s condition, panic, or simply the caregiver’s wish to have an independent person confirm death. EMS personnel should not be surprised by these situations. Prompt consultation with the direct medical oversight physician may be appropriate in these situations.

A recent initiative, Physician Orders for Life-Sustaining Treatment (POLST), is an effort to provide a uniform DNR order sheet transcending prehospital, hospital, and long-term care settings. A number of states are enacting legislation for this program. The specific operational details must be implemented prospectively to avoid confusion and misunderstanding at the patient’s side.

**Dead on arrival**

Non-initiation of resuscitation may be appropriate in certain situations when lividity, rigor mortis, decomposition, and other signs of obvious death are present. Protocols should specify when EMS personnel should and should not initiate resuscitation. These guidelines should address special circumstances, such as hypothermia and trauma, in addition to medical arrests. Consultation with the direct medical oversight physician is prudent in unclear situations.

Protocols should also detail specific tasks that EMS personnel must carry out after non-initiation of resuscitation, including notification of police, the coroner, or the medical examiner. EMS providers should also receive training in providing emotional support to family and bystanders.

**Termination of resuscitation**

Traditionally, in many areas EMS crews transported all cardiac arrest victims to the hospital, continuing resuscitative efforts en route. However, there is growing awareness that cardiac arrest patients who are not responding to initial treatment will likely not receive additional benefit from transport to the hospital [80]. Therefore, many EMS agencies now have protocols for terminating resuscitation efforts in the field.

Several studies have evaluated the prediction of futility by BLS providers [81–85]. The Verbeek/Morrison rule indicates termination of resuscitation in patients with an unwitnessed arrest after three periods of CPR, three AED analyses without shock recommendation, and no ROSC [85].

Patients who receive appropriate initial ACLS (including airway management and IV access) and who remain in asystole or PEA for greater than 20–30 minutes of resuscitative efforts without return of pulses are unlikely to be resuscitated [83,85]. ACLS guidelines support cessation of efforts in these patients without transport to the hospital [1,80,82,84]. Consultation with the direct medical oversight physician may be appropriate in these cases. Non-transport after termination of efforts applies only to patients with sustained pulselessness from suspected cardiac etiologies. This approach does *not* apply to patients with drug overdoses, hypothermic arrest, or other special situations.

The decision to terminate resuscitation or transport to the hospital involves important social and ethical concerns. Although some express concern that cessation of resuscitative efforts at the scene may be poorly accepted, two studies suggest that non-transport is well accepted and often preferred if proper counseling and explanation are given to bystanders and family members [86,87]. Nonetheless, there may be circumstances in which transport to the hospital may be prudent (e.g. cardiac arrests occurring in public locations, unexpected death in the very young, and situations with extremely distraught or unaccepting family members). Paramedics are often uncomfortable terminating resuscitation in children [88]. Direct medical oversight physician input may prove helpful in these situations.

As resuscitation strategies and postarrest care continue to improve, the accepted criteria for termination of resuscitation will have to be reevaluated. See Volume 1, [Chapter 65](https://jigsaw.vitalsource.com/books/9781118990827/epub/OPS/c65.xhtml) for additional information on termination of resuscitation.

**Postarrest care**

A common misconception is that the resuscitation ends after restoration of pulses. In fact, the body is in an extremely tenuous state in the immediate postarrest period. Without proper support, cardiac arrest may recur. In essence, the restoration of pulses represents the *beginning* of postarrest care.

The goals of postarrest care are to maintain hemodynamic stability, preserve the brain, and correct metabolic derangements. The salient elements of postarrest care include:

* vasopressor titration
* therapeutic hypothermia
* appropriate cardiac catheterization
* sedation
* glucose and electrolyte management.

The most important EMS consideration is vasopressor support after ROSC. Animal models of cardiac arrest predictably develop cardiovascular collapse shortly after ROSC [89]. This hemodynamic instability may result from myocardial stunning as well as the waning effect of epinephrine [90–93]. These patients frequently require vasopressor support. Because of the likely need for vasopressor support, it is reasonable to prepare a dopamine, norepinephrine, or epinephrine infusion immediately after achieving ROSC. Rescuers need to anticipate cardiovascular collapse. If they wait for collapse to occur, the patient will deteriorate before rescue therapy can be initiated.

Coronary artery disease is common in this population, and is independent of the primary arrest rhythm [94]. Early coronary angiography is strongly supported in guideline statements and has been associated with improved outcomes following ROSC [94,95]. Consequently, 12-lead ECG analysis is indicated in the patient successfully resuscitated from cardiac arrest. Patients with a history consistent with acute coronary syndrome or obvious ECG changes should be transported to a percutaneous coronary intervention center and receive prompt coronary angiography.

The induction of mild hypothermia for brain preservation has demonstrated significant improvement in neurological outcome in comatose patients following cardiac arrest [96,97]. Hypothermia is believed to decrease cerebral metabolism, reduce free radical production, and impose direct protective effects on neural and cardiac tissue [98–102].

In the Hypothermia After Cardiac Arrest (HACA) study, comatose survivors of VF/VT cardiac arrest were randomized to a goal temperature of 32–34°C for 24 hours or normal care and normothermia [96]. The investigators noted that 55% of patients receiving hypothermia enjoyed a good outcome (defined as a Cerebral Performance Category 1 [Good Recovery] or 2 [Moderate Disability]) compared with 39% of normothermic patients. In the Bernard study, patients were randomized to a goal temperature of 33°C for 12 hours or normal care and normothermia [97]. Further, 49% of the hypothermic patients enjoyed a good outcome (defined as discharge home or to acute rehabilitation), compared with 26% of the normothermic patients.

Therapeutic hypothermia has an AHA Class I recommendation for comatose survivors of out-of-hospital VT/VF cardiac arrest and a Class IIb recommendation for other rhythms or in-hospital cardiac arrests [103]. Recent evidence suggests that controlling temperature between 32–36°C results in similar outcomes in the out-of-hospital VF/VT population [104].

Early prehospital induction of hypothermia is empirically appealing and supported by animal studies. Kim et al. have demonstrated that induction of hypothermia during the prehospital phase is feasible [105,106]. The Bernard trial initiated cooling in the ambulance while en route to the hospital [97]. Perhaps the most compelling reason for starting hypothermia in the field is that hospital personnel often fail to initiate the therapy [107–111]. Initiation of hypothermia by EMS personnel may remind or compel hospital caregivers to continue this intervention.

Induction of hypothermia is relatively simple, does not require specialized techniques, and can be initiated in the prehospital setting. Kim et al. noted that rapid infusion of 1–2 L of cold (4°C) saline resulted in a 1° drop in patient temperature in the first 30 minutes [105]. Bernard et al. used surface cooling with skin exposure and ice packs, an approach that is slower but complementary [97]. Moore et al. demonstrated that healthy volunteers could achieve a 1° temperature drop with infusion of 30 mL/kg of cold saline during a 30-minute infusion [112]. The initial temperature in many postarrest patients is approximately 35–35.5°C [113]. Therefore, practitioners may potentially reach the target temperature with only a 1° reduction in body temperature. In the largest randomized controlled trial to date, prehospital cooling was not associated with a higher rate of good neurological outcome than the hospital-initiated group (risk ratio 0.90; 95% CI 0.70, 1.17) [114]. In addition, recent data demonstrate that rapid infusion of saline in the prehospital arena is associated with pulmonary edema [115]. To date, intraarrest hypothermia has not yielded additional survival benefit [116]. Nasogastric, bladder, and endovascular cooling are other viable options in the hospital, but they are impractical in the prehospital setting.

Most importantly, the receiving medical facility must continue hypothermia therapy for it to be effective. The EMS physician should ensure that a patient cooled in the prehospital arena is transported to a facility that can continue this therapy. Although the ultimate target temperature is 32–34°C, this goal may require several hours with concomitant sedation and pharmacological paralysis.

The other elements of postarrest care do not need to be initiated in the field. However, the postarrest patient is critically ill and frequently requires the care of multiple specialists who may not be available at all hospital facilities [110,117–120]. The management of the postarrest patient is a low-frequency, resource-intensive event requiring regimented, multidisciplinary strategies to optimize outcome [118,120]. One retrospective study has demonstrated that the risk of rearrest during prolonged air medical transport is low, but critical events such as hypotension or hypoxemia were encountered in 23% of patients [121]. Because many hospitals cannot provide these services at all hours, some systems have regionalized the care of postarrest patients [122]. EMS medical directors should consider developing policy regarding the proper destination for postarrest patients in their systems.

**Conclusion**

Successful resuscitation of patients from out-of-hospital cardiac arrest requires a comprehensive system of care. Prehospital care providers face many practical and logistical challenges in this setting, but intense, expert resuscitation efforts can improve the bleak rate of survival from this condition. Prompt initiation and continuous performance of high-quality chest compressions, timely defibrillation, avoidance of hyperventilation, and appropriate postarrest care are the keys to successful outcomes.