Part 8: Post–Cardiac Arrest Care

2015 American Heart Association Guidelines Update for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care

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Introduction

The recommendations in this *2015 American Heart Association* (AHA) *Guidelines Update for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care* are based on an extensive evidence review process that was begun by the International Liaison Committee on Resuscitation (ILCOR) after the publication of the *2010 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations*[1,2] and was completed in February 2015.[3,4]

In this in-depth evidence review process, ILCOR examined topics and then generated a prioritized list of questions for systematic review. Questions were first formulated in PICO (population, intervention, comparator, outcome) format,[5] and then search strategies and inclusion and exclusion criteria were defined and a search for relevant articles was performed. The evidence was evaluated by the ILCOR task forces by using the standardized methodological approach proposed by the Grading of Recommendations Assessment, Development and Evaluation (GRADE) Working Group.[6]

The quality of the evidence was categorized based on the study methodologies and the 5 core GRADE domains of risk of bias, inconsistency, indirectness, imprecision, and other considerations (including publication bias). Then, where possible, consensus-based treatment recommendations were created.

To create this 2015 Guidelines Update, the AHA formed 15 writing groups, with careful attention to manage conflicts of interest, to assess the ILCOR treatment recommendations and to write AHA treatment recommendations by using the AHA Class of Recommendation (COR) and Level of Evidence (LOE) system. The recommendations made in the Guidelines are informed by the ILCOR recommendations and GRADE classification, in the context of the delivery of medical care in North America. The AHA writing group made new recommendations only on topics specifically reviewed by ILCOR in 2015. This chapter delineates instances where the AHA writing group developed recommendations that are significantly stronger or weaker than the ILCOR statements. In the online version of this publication, live links are provided so the reader can connect directly to the systematic reviews on the Scientific Evidence Evaluation and Review System (SEERS) website. These links are indicated by a combination of letters and numbers (eg, ALS 790). We encourage readers to use the links and review the evidence and appendixes, including the GRADE tables.

This update uses the newest AHA COR and LOE classification system, which contains modifications of the Class III recommendation and introduces LOE B-R (randomized studies) and B-NR (nonrandomized studies) as well as LOE C-LD (limited data) and LOE C-EO (consensus of expert opinion). All recommendations made in this 2015 Guidelines Update, as well as in the 2010 Guidelines for post–cardiac arrest care, are listed in the Appendix. For further information, see "Part 2: Evidence Evaluation and Management of Conflicts of Interest" in this 2015 Guidelines Update.

Overview of Post–Cardiac Arrest Care

The 2010 Guidelines emphasized that cardiac arrest can result from many different diseases. Regardless of cause, the hypoxemia, ischemia, and reperfusion that occur during cardiac arrest and resuscitation may cause damage to multiple organ systems.[7] The severity of damage can vary widely among patients and among organ systems within individual patients. Therefore, effective post–cardiac arrest care consists of identification and treatment of the precipitating cause of cardiac arrest combined with the assessment and mitigation of ischemia-reperfusion injury to multiple organ systems. Care must be tailored to the particular disease and dysfunction that affect each patient. Therefore, individual patients may require few, many, or all of the specific interventions discussed in the remainder of this Part.

Cardiovascular Care

Acute Cardiovascular Interventions[ACS 340, ACS 885]

The 2010 Guidelines recommended obtaining a 12-lead electrocardiogram (ECG) as soon as possible after return of spontaneous circulation (ROSC) to identify if acute ST elevation is present, and to perform urgent coronary angiography with prompt recanalization of any infarct-related artery in select

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post–cardiac arrest patients in whom ST-segment elevation was identified. Acute coronary syndromes are a common etiology for out-of-hospital cardiac arrest (OHCA) in adults with no obvious extracardiac cause of arrest[8–10] and also can precipitate some in-hospital cardiac arrest. In series in which consecutive post–cardiac arrest patients with suspected cardiovascular cause were taken to coronary angiography, a coronary artery lesion amenable to emergency treatment was found in 96% of patients with ST elevation and in 58% of patients without ST elevation.[10]

The 2015 ILCOR systematic review examined immediate coronary angiography for patients after cardiac arrest.

2015 Evidence Summary

Numerous observational studies evaluate the relationship between coronary angiography, survival, and functional outcome in post–cardiac arrest patients, but there are no prospective randomized trials evaluating an interventional strategy in postarrest patients. The timing of immediate coronary angiography was defined in various ways in different studies, but all studies considered immediate angiography as a procedure performed on the same day as the cardiac arrest, as opposed to later in the hospital stay. Fifteen observational studies reported improved survival to hospital discharge associated with emergency coronary angiography in patients with ST elevation after cardiac arrest.[11–25] Nine observational studies showed improved neurologically favorable outcome associated with emergency coronary angiography in patients with ST elevation after cardiac arrest.[11–13,16,18–21,23]

Fewer data are available to evaluate coronary angiography in patients without ST elevation on the initial ECG. Two observational studies reported improved survival to hospital discharge and improved neurologically favorable outcome associated with emergency coronary angiography in patients without ST elevation on initial ECG.[11,16]

2015 Recommendations—Updated

Coronary angiography should be performed emergently (rather than later in the hospital stay or not at all) for OHCA patients with suspected cardiac etiology of arrest and ST elevation on ECG (Class I, LOE B-NR).

Emergency coronary angiography is reasonable for select (eg, electrically or hemodynamically unstable) adult patients who are comatose after OHCA of suspected cardiac origin but without ST elevation on ECG (Class IIa, LOE B-NR).

Coronary angiography is reasonable in post–cardiac arrest patients for whom coronary angiography is indicated regardless of whether the patient is comatose or awake (Class IIa, LOE C-LD).

Early invasive approaches are preferred for patients with ST-segment elevation myocardial infarction (STEMI), making these recommendations for post–cardiac arrest patients consistent with global recommendations for all patients with STEMI.[26] Early invasive approaches also are suggested for treatment of select post–cardiac arrest patients with acute coronary syndromes without ST elevation. Considerations for selecting patients are complex and may consider factors such as hemodynamic or electrical instability as well as comorbidities, evidence of ongoing ischemia, and other patient characteristics.[27] Knowledge of coronary anatomy and opportunity for placement of temporary support devices are other potential benefits derived from early catheterization. Therefore, these recommendations for post–cardiac arrest care are consistent with recommendations for all patients with non-STEMI acute coronary syndromes. Both the European Society of Cardiology and the combined entity of the American College of Cardiology Foundation and the AHA have published STEMI guidelines recommending immediate coronary angiography, and percutaneous coronary intervention when indicated, for resuscitated OHCA patients whose ECGs show STEMI.[26,28] None of these guidelines recommended different treatment of patients based on the initial cardiac arrest rhythm (ventricular fibrillation [VF] or non-VF).

Previous consensus statements have discussed how public reporting of postprocedure death creates an incentive to avoid emergency coronary angiography in comatose patients who are at higher risk of death as a consequence of poor neurologic recovery.[29] However, the probability of neurologic recovery cannot be determined reliably at the time that emergency cardiovascular interventions are performed (see Prognostication of Outcome section in this Part). Therefore, the best care for the patient requires separation of decisions about cardiovascular intervention from assessment of neurologic prognosis.

Hemodynamic Goals[ALS 570]

Post–cardiac arrest patients are often hemodynamically unstable, which can occur for multiple reasons that include the underlying etiology of the arrest as well as the ischemia-reperfusion injury from the arrest. Management of these patients can be challenging, and optimal hemodynamic goals remain undefined. In 2015, ILCOR evaluated the optimal hemodynamic targets in post–cardiac arrest patients, primarily considering blood pressure goals.

2015 Evidence Summary

There are several observational studies evaluating the relationship between blood pressure and outcome in post–cardiac arrest patients, but there are no interventional studies targeting blood pressure in isolation and no trials evaluating one specific strategy for improving blood pressure over another (ie, fluids, vasopressors). Observational studies found that post–cardiac arrest systolic blood pressure less than 90 mm Hg[30,31] or greater than 100 mm Hg[32] was associated with higher mortality and diminished functional recovery. One observational study found that mean arterial pressure (MAP) greater than 100 mm Hg during 2 hours after ROSC was associated with better neurologic recovery at hospital discharge.[33] Another observational study found that survivors, compared with nonsurvivors, had higher MAP at 1 hour (96 versus 84 mm Hg) and at 6 hours (96 versus 90 mm Hg).[34]

While no studies evaluated blood pressure in isolation, several before-and-after studies implemented bundles of care that included blood pressure goals. In these studies, the individual effect of blood pressure was impossible to separate from the effects of the remainder of the bundle. One bundle with a MAP target of greater than 80 mm Hg improved mortality and neurologic outcome at hospital discharge.[35] One bundle with a goal of MAP over 75 mm Hg found no change in functional recovery at hospital discharge.[36] One bundle with

MAP greater than 65 mm Hg increased survival to hospital discharge, with a favorable neurologic outcome at 1 year.[37] Another bundle with a goal MAP greater than 65 mm Hg within 6 hours found no change in in-hospital mortality or functional recovery at hospital discharge.[38]

2015 Recommendation—New

Avoiding and immediately correcting hypotension (systolic blood pressure less than 90 mm Hg, MAP less than 65 mm Hg) during postresuscitation care may be reasonable (Class IIb, LOE C-LD).

A specific MAP or systolic blood pressure that should be targeted as part of the bundle of postresuscitation interventions could not be identified, although published protocols targeted MAP goals of greater than 65 mm Hg to greater than 80 mm Hg. Moreover, identifying an optimal MAP goal for the overall patient population may be complicated by individual patient variability, because baseline blood pressures vary among patients. The true optimal blood pressure would be that which allows for optimal organ and brain perfusion, and different patients and different organs may have different optimal pressures.

Targets for other hemodynamic or perfusion measures (such as cardiac output, mixed/central venous oxygen saturation, and urine output) remain undefined in post–cardiac arrest patients. The systematic reviews did not identify specific targets for other variables, and individual goals likely vary based on patient-specific comorbidities and underlying physiology. In the absence of evidence for specific targets, the writing group made no recommendations to target any hemodynamic goals other than those that would be used for other critically ill patients.

Targeted Temperature Management

The 2010 Guidelines strongly advised induced hypothermia (32ºC to 34ºC) for the subgroup of patients with out-of-hospital VF/pulseless ventricular tachycardia (pVT) cardiac arrest and post-ROSC coma (the absence of purposeful movements), and encouraged that induced hypothermia be considered for most other comatose patients after cardiac arrest. Precise duration and optimal temperature targets were unknown, and the Guidelines recommended 12 to 24 hours at 32ºC to 34ºC based on the regimens studied in prior trials. The 2015 ILCOR systematic review identified multiple new randomized controlled trials testing different target temperatures and different timing for initiation of temperature control after cardiac arrest.[39] Reflecting that a variety of temperature targets are now used, the term *targeted temperature management* (TTM) has been adopted to refer to induced hypothermia as well as to active control of temperature at any target.

Induced Hypothermia ALS 790, ALS 791

2015 Evidence Summary

For patients with VF/pVT OHCA, combined outcome data from 1 randomized and 1 quasi-randomized clinical trial reported increased survival and increased functional recovery with induced hypothermia to 32ºC to 34ºC.[40,41]

For patients with OHCA and nonshockable rhythms, observational data were conflicting and no randomized data were available. Three observational studies found no difference in neurologic outcome at hospital discharge in patients treated with induced hypothermia.[42–44] One study reported an increase in poor neurologic outcome at hospital discharge; however, the analysis of this study was confounded perhaps most notably by lack of information on whether analyzed patients were eligible for induced hypothermia (ie, unknown if patients were following commands).[45] One study reported reduced mortality at 6 months with induced hypothermia.[43]

For patients with in-hospital cardiac arrest, no randomized data were available. One observational study found no association between induced hypothermia and survival or functionally favorable status at hospital discharge. However, the analysis of this study was also confounded by multiple factors, including the lack of information on which patients were comatose and, therefore, potential candidates for induced hypothermia.[46]

One well-conducted randomized controlled trial found that neurologic outcomes and survival at 6 months after OHCA were not superior when temperature was controlled at 36ºC versus 33ºC.[47] Both arms of this trial involved a form of TTM as opposed to no TTM.

There are no direct comparisons of different durations of TTM in post–cardiac arrest patients. The largest trials and studies of TTM maintained temperatures for 24 hours[40] or 28 hours[47] followed by a gradual (approximately 0.25ºC/hour) return to normothermia.

2015 Recommendations—Updated

We recommend that comatose (ie, lack of meaningful response to verbal commands) adult patients with ROSC after cardiac arrest have TTM (Class I, LOE B-R for VF/pVT OHCA; Class I, LOE C-EO for non-VF/pVT (ie, "nonshockable") and in-hospital cardiac arrest).

We recommend selecting and maintaining a constant temperature between 32ºC and 36ºC during TTM (Class I, LOE B-R).

In making these strong recommendations, the writing group was influenced by the recent clinical trial data enrolling patients with all rhythms, the rarity of adverse effects in trials, the high neurologic morbidity and mortality without any specific interventions, and the preponderance of data suggesting that temperature is an important variable for neurologic recovery. Of note, there are essentially no patients for whom temperature control somewhere in the range between 32ºC and 36ºC is contraindicated. Specific features of the patient may favor selection of one temperature over another for TTM. Higher temperatures might be preferred in patients for whom lower temperatures convey some risk (eg, bleeding),[48,49] and lower temperatures might be preferred when patients have clinical features that are worsened at higher temperatures (eg, seizures, cerebral edema).[50–52] Therefore, all patients in whom intensive care is continued are eligible. The initial temperature of the patient may influence selection of the temperature for TTM. For example, those who present at the lower end of the TTM range might be maintained at that lower temperature (as opposed to warming them to a higher target). Alternatively, passive warming to a maximum temperature of 36ºC might be acceptable as well. Of note is that the recent randomized trial did not use active warming for the 36ºC group.[47] Therefore, while it is stated that choosing a temperature within the 32ºC to 36ºC range is acceptable, actively or rapidly warming patients is not suggested. Conversely, patients who present on

the higher end of the TTM range might be kept at 36ºC without much additional effort. Providers should note that allowing patients to warm to temperatures above 36ºC would be more akin to the control group of the earlier trials and not consistent with the current TTM recommendations.

The recommendations for TTM for nonshockable rhythms and for patients following in-hospital arrest are stronger than those made in 2015 by ILCOR[3,4] and are stronger than the recommendations in "Part 9: Post–Cardiac Arrest Care" in the 2010 Guidelines. The writing group felt that the option for TTM at 36ºC diminished theoretical concerns about side effects of TTM for these populations. In addition, the writing group was influenced by the high rate of neurologic morbidity in historical cohorts that did not use TTM.

It is reasonable that TTM be maintained for at least 24 hours after achieving target temperature (Class IIa, LOE C-EO).

Even if the selected target temperature is not achieved during this time frame, clinicians should still try to control temperature for at least 24 hours after cardiac arrest. Temperature sensitivity of the brain after cardiac arrest may continue for as long as brain dysfunction (ie, coma) is present, making the upper limit of duration for temperature management unknown. The duration of at least 24 hours was used in 2 of the largest trials, although there are no comparative data for this duration. For these reasons, 24 hours was selected as the minimum recommended time for TTM.

Hypothermia in the Prehospital Setting[ALS 802]

The initiation of hypothermia has been popularized in the prehospital setting, though the original studies showing efficacy from induced hypothermia did not systematically study the prehospital setting. A logical assumption for the widespread implementation of this practice stemmed from the concept that earlier provision of an effective intervention would be more beneficial. However, induction of prehospital hypothermia was not extensively evaluated by large-scale randomized trials in 2010. Since that time, a number of additional trials have been published, including at least 1 large-scale investigation. In 2015, ILCOR examined the question of whether early provision of TTM was beneficial, with a focus on the prehospital period.

2015 Evidence Summary

Five randomized controlled trials[53–57] compared the post-ROSC use of cold intravenous fluids to induce hypothermia to no fluids. One trial compared cold intravenous fluid during resuscitation to no cooling,[58] and another trial compared intra-arrest intranasal cooling to no cooling.[59] When cooling maneuvers were initiated in the prehospital setting, neither survival nor neurologic recovery differed for any of these trials alone or when combined in a meta-analysis. One trial found an increase in pulmonary edema and rearrest among patients treated with a goal of prehospital infusion of 2 L of cold fluids.[57]

2015 Recommendation—New

We recommend **against** the routine prehospital cooling of patients after ROSC with rapid infusion of cold intravenous fluids (Class III: No Benefit, LOE A).

During the past few years, infusion of cold intravenous fluids has become a popular prehospital intervention that may influence the system of care. Initiation of a temperature management strategy en route to the hospital may increase the probability that temperature management continues during the hospitalization. Adverse effects of the rapid infusion of cold intravenous fluids in the prehospital setting must be weighed against this potential positive effect of earlier intervention. Current evidence indicates that there is no direct patient benefit from these interventions and that the intravenous fluid administration in the prehospital setting may have some potential harm, albeit with no increase in overall mortality. Whether different methods or devices for temperature control outside of the hospital are beneficial is unknown.

Avoidance of Hyperthermia[ALS 879]

After the completion of TTM for a set duration (such as 24 hours), the optimal approach to subsequent temperature management remains unknown. In 2015, the ILCOR systematic review evaluated both the approach to hyperthermia on presentation (before initiation of TTM) and after rewarming. The treatment recommendation to maintain a targeted temperature between 32ºC and 36ºC for postarrest patients will prevent early hyperthermia. Therefore, treatment recommendations for the avoidance of hyperthermia focus on the post-rewarming period.

2015 Evidence Summary

Observational studies consistently report that fever in the post–cardiac arrest patient who is not treated with TTM is associated with poor outcome.[60–64]

After rewarming to normothermia from TTM, many studies have noted that fever occurs in a significant proportion of patients.[64–71] Occurrence of hyperthermia during the first few days after cardiac arrest was associated with worse outcome in 2 studies[70,71] but not in others.[64–69]

2015 Recommendation—New

It may be reasonable to actively prevent fever in comatose patients after TTM (Class IIb, LOE C-LD).

Fever will not occur during the first 24 to 48 hours after cardiac arrest when patients are treated with TTM. Though the evidence that supports avoiding hyperthermia is weak in postarrest patients, the intervention is relatively benign. In addition, fever is associated with worsened neurologic injury in comatose patients receiving intensive care for other conditions.[72,73] Therefore, the recommendation of the avoidance of fever is based on expert opinion that a relatively benign procedure is reasonable to perform in the face of a potential for worsening ischemic brain injury. The simplest method to accomplish prolonged hyperthermia prevention may be to leave the devices or strategies used for TTM in place.

Other Neurologic Care

The 2010 Guidelines emphasized advanced neurocritical care for patients who have brain injury after cardiac arrest, including electroencephalography (EEG) for detection of seizures, and prompt treatment of seizures. The 2015 ILCOR systematic review considered detection and treatment of seizures.

Seizure Management[ALS 868, ALS 431]

2015 Evidence Summary

The prevalence of seizures, nonconvulsive status epilepticus, and other epileptiform activity among patients who are comatose after cardiac arrest is estimated to be 12% to 22%.[74–76] Nonconvulsive status epilepticus may be a reason that patients are not awakening from coma. Three case series looked at 47 post–cardiac arrest patients who were treated for seizures or status epilepticus and found that only 1 patient survived with good neurologic function.[77–79]

Available evidence does not support prophylactic administration of anticonvulsant drugs. Two randomized clinical trials comparing anticonvulsants (thiopental[80] in one study and diazepam[74] in the other study) to placebo found no difference in any outcome when these drugs were administered shortly after ROSC. In addition, 1 nonrandomized clinical trial with historic controls did not find outcome differences when a combination of thiopental and phenobarbital[81] was provided after ROSC.

Prolonged epileptiform discharges are associated with secondary brain injury in other situations, making detection and treatment of nonconvulsive status epilepticus a priority.[82] However, there are no direct comparative studies in post–cardiac arrest patients of treating seizures versus not treating seizures. The 2015 ILCOR systematic review did not identify any evidence that 1 specific drug or combination of drugs was superior for treatment of epileptiform activity after cardiac arrest.

2015 Recommendations—Updated

An EEG for the diagnosis of seizure should be promptly performed and interpreted, and then should be monitored frequently or continuously in comatose patients after ROSC (Class I, LOE C-LD).

The same anticonvulsant regimens for the treatment of status epilepticus caused by other etiologies may be considered after cardiac arrest (Class IIb, LOE C-LD).

Respiratory Care

The 2010 Guidelines emphasized the identification of pulmonary dysfunction after cardiac arrest. The 2015 ILCOR systematic review evaluated whether a particular strategy of ventilator management should be employed for postarrest patients, with a specific focus on a target range for $Paco_2$.

Ventilation[ALS 571]

2015 Evidence Summary

Systematic reviews examined whether ventilation to achieve and maintain a particular $Paco_2$ was associated with improved outcome. Two observational studies[83,84] found hypocapnia to be associated with a worse neurologic outcome, and 1 observational study found hypocapnia was associated with failure to be discharged home.[85] Observational studies did not find any consistent association between hypercapnia and outcome.[83–86]

2015 Recommendation—Updated

Maintaining the $Paco_2$ within a normal physiological range, taking into account any temperature correction, may be reasonable (Class IIb, LOE B-NR).

Normocarbia (end-tidal CO_2 30–40 mm Hg or $Paco_2$ 35–45 mm Hg) may be a reasonable goal unless patient factors prompt more individualized treatment. Other $Paco_2$ targets may be tolerated for specific patients. For example, a higher $Paco_2$ may be permissible in patients with acute lung injury or high airway pressures. Likewise, mild hypocapnia might be useful as a temporizing measure when treating cerebral edema, but hyperventilation might cause cerebral vasoconstriction. The need to avoid potential hyperventilation-induced cerebral vasoconstriction needs to be weighed against the correction of metabolic acidosis by hyperventilation. Providers should note that when patient temperature is below normal, laboratory values reported for $Paco_2$ might be higher than the actual values in the patient.

Oxygenation[ALS 448]

Previous guidelines suggested that the optimal titration of supplementary oxygen targets avoidance of prolonged hyperoxia. Episodes of hypoxia that can add to organ injury should also be prevented.

2015 Evidence Summary

The systematic review identified recent observational studies suggesting that excessively high arterial oxygen concentrations (hyperoxia) may harm various organs or worsen outcomes.[87–89] Other studies did not confirm this finding.[83,86,90–92] One small randomized trial comparing 30% inspired oxygen for 60 minutes after ROSC versus 100% inspired oxygen for 60 minutes after ROSC found no difference in either survival to hospital discharge or survival with favorable neurologic outcome.[93] Most studies defined hypoxia as Pao_2 less than 60 mm Hg, and hyperoxia as a Pao_2 greater than 300 mm Hg. However, the optimum upper and lower limits of Pao_2 are not known.

The 2010 Guidelines defined an arterial oxygen saturation (Sao_2) of less than 94% as hypoxemia, and there were no new data to suggest modifying this threshold. Minimizing risk of hyperoxia must be weighed against the need to avoid hypoxia, which has a well established detrimental effect.[88,91,94] Preventing hypoxic episodes is considered more important than avoiding any potential risk of hyperoxia.

2015 Recommendations—New and Updated

To avoid hypoxia in adults with ROSC after cardiac arrest, it is reasonable to use the highest available oxygen concentration until the arterial oxyhemoglobin saturation or the partial pressure of arterial oxygen can be measured (Class IIa, LOE C-EO).

When resources are available to titrate the Fio_2 and to monitor oxyhemoglobin saturation, it is reasonable to decrease the Fio_2 when oxyhemoglobin saturation is 100%, provided the oxyhemoglobin saturation can be maintained at 94% or greater (Class IIa, LOE C-LD).

Shortly after ROSC, patients may have peripheral vasoconstriction that makes measurement of oxyhemoglobin saturation by pulse oximetry difficult or unreliable. In those situations, arterial blood sampling may be required before titration of Fio_2. Attempts to limit the concentration of inspired oxygen rely on having proper equipment available. For example, oxygen blenders may not be available immediately after return of pulses, and these recommendations remind providers using bag-mask devices and oxygen cylinders to simply provide the highest available oxygen concentration until titration is possible.

Other Critical Care Interventions

Glucose Control[ALS 580]

The 2010 Guidelines acknowledged that the optimum blood glucose concentration and interventional strategy to manage blood glucose in the post–cardiac arrest period are unknown. Glycemic control in critically ill patients is controversial, and efforts to tightly control glucose at low levels have been associated with increased frequency of hypoglycemic episodes that may be detrimental.

2015 Evidence Summary

The 2015 ILCOR systematic review found no new evidence that a specific target range for blood glucose management improved relevant clinical outcomes after cardiac arrest. One randomized trial in post–cardiac arrest patients comparing strict (72 to 108 mg/dL) versus moderate (108 to 144 mg/dL) glucose control found no difference in 30-day mortality.[95] One before-and-after study of a bundle of care that included a target glucose range (90 to 144 mg/dL) reported better survival and functional recovery at hospital discharge, but the effects of glucose control could not be separated from the remainder of the bundle.[37] No data suggest that the approach to glucose management chosen for other critically ill patients should be modified for cardiac arrest patients.[96–98]

2015 Recommendation—Updated

The benefit of any specific target range of glucose management is uncertain in adults with ROSC after cardiac arrest (Class IIb, LOE B-R).

Prognostication of Outcome

The 2010 Guidelines discussed the use of clinical examination, electrophysiologic measurements, imaging studies, and evaluation of blood or cerebrospinal fluid markers of brain injury to estimate the prognosis for neurologic improvement in patients who are comatose after cardiac arrest. The 2015 ILCOR systematic review examined numerous studies of the diagnostic accuracy of clinical findings, electrophysiologic modalities, imaging modalities, and blood markers for predicting neurologic outcome in comatose post–cardiac arrest patients who receive TTM, and examined recent studies of these modalities in comatose post–cardiac arrest patients who do not receive TTM. Updated guidelines for prognostication have also been proposed by other international organizations.[99]

Most studies examined the accuracy of diagnostic tests for predicting a poor outcome (as defined by a Cerebral Performance Category score of 3 to 5) and focused on patients receiving TTM with a goal of 32°C to 34°C. The writing group assumed that the accuracy of prognostic tests is similar in patients receiving TTM with a goal of 36°C when similar sedation and paralysis are used as in patients receiving TTM with a goal of 32°C to 34°C. Recognizing the need for high certainty when predicting that outcomes will be poor, the writing group focused recommendations on diagnostic tests for which the systematic review identified false-positive rates (FPRs) close to 0%, with narrow 95% confidence intervals (CIs; 0%–10%).

Experienced clinicians should select the proper tests and studies for individual patients. Some patients will recover quickly and will require no special testing. For other patients, prediction of their recovery trajectory may be impossible despite collecting every available test and imaging study. The following recommendations are designed to provide guidance to clinicians about the performance of specific findings and tests, recognizing that not every patient will require every study.

Timing of Outcome Prediction[ALS 450, ALS 713]

It is important to consider the optimal timing for prognostication in post–cardiac arrest patients. In 2015, the ILCOR task force evaluated the timing of prognostication for patients receiving TTM and for those not receiving TTM.

2015 Evidence Summary

Sedatives or neuromuscular blockers received during TTM may be metabolized more slowly in post–cardiac arrest patients, and injured brains may be more sensitive to the depressant effects of various medications. Residual sedation or paralysis can confound the accuracy of clinical examinations.[100,101] The optimal time for prognostication is when the FPRs of the various prognostic tools approach zero. Multiple investigations suggest that it is necessary to wait to prognosticate for a minimum of 72 hours after ROSC to minimize the rate of false-positive results in patients who had not undergone TTM[102] and to wait for some period of time after return of normothermia for those using TTM.[103]

2015 Recommendations—New and Updated

The earliest time for prognostication using clinical examination in patients treated with TTM, where sedation or paralysis could be a confounder, may be 72 hours after return to normothermia (Class IIb, LOE C-EO).

We recommend the earliest time to prognosticate a poor neurologic outcome using clinical examination in patients not treated with TTM is 72 hours after cardiac arrest (Class I, LOE B-NR). This time until prognostication can be even longer than 72 hours after cardiac arrest if the residual effect of sedation or paralysis confounds the clinical examination (Class IIa, LOE C-LD).

Operationally, the timing for prognostication is typically 4.5 to 5 days after ROSC for patients treated with TTM. This approach minimizes the possibility of obtaining false-positive results (ie, inaccurately suggesting a poor outcome) because of drug-induced depression of neurologic function. In making this recommendation, it is recognized that in some instances, withdrawal of life support may occur appropriately before 72 hours because of underlying terminal disease, brain herniation, or other clearly nonsurvivable situations.

Clinical Examination Findings That Predict Outcome[ALS 450, ALS 713]

Prediction of outcome based on clinical examination may be challenging. In 2015, the ILCOR Advanced Life Support Task Force evaluated a series of clinical exam findings to determine their value in outcome prediction.

2015 Evidence Summary

The 2015 ILCOR systematic review examined pupillary light reflexes, corneal reflexes, and motor response for prediction

of poor functional recovery in patients treated with TTM. Bilaterally absent pupillary light reflex at 72 to 108 hours after cardiac arrest predicted poor outcome, with an FPR of 1% (95% CI, 0%–3%).[104–108] Bilaterally absent corneal reflexes at 72 to 120 hours after cardiac arrest predicted poor outcome, with a 2% FPR (95% CI, 0%–7%).[106–109] Extensor posturing or no motor response to pain at 36 to 108 hours after cardiac arrest predicted poor outcome, with a 10% FPR (95% CI, 7%–15%).[104,106,108,110–112] Only the absent pupillary light reflex at 72 to 108 hours achieved an FPR of 0% (95% CI, 0%–3%).

In patients not treated with TTM, absent pupillary light reflex 72 hours after cardiac arrest predicts poor outcome, with 0% FPR (95% CI, 0%–8%).[113,114] Absent corneal reflex at 24 hours and 48 hours after cardiac arrest predicted poor outcome, with an FPR of 17% (95% CI, 9%–27%) and an FPR of 7% (95% CI, 2%–20%), respectively.[114–116] Extensor posturing or no motor response to pain at 72 hours after cardiac arrest predicted a poor outcome, with 15% FPR (95% CI, 5%–31%).[114,117] As in TTM-treated patients, only the absent pupillary light reflex at 72 to 108 hours achieved 0% FPR (95% CI, 0%–8%).

The 2015 ILCOR systematic review distinguished myoclonus from status myoclonus (continuous, repetitive myoclonic jerks lasting more than 30 minutes) in patients treated with TTM. Any myoclonus within 72 hours after cardiac arrest predicted a poor outcome, with a 5% FPR (95% CI, 3%–8%).[78,104,110,111,118,119] In 1 study,[112] presence of myoclonus within 7 days after ROSC predicted poor outcome, with 11% FPR (95% CI, 3%–26%) and 54% FPR (95% CI, 41%–66%) sensitivity. In 3 studies,[75,107,108] presence of status myoclonus (defined as a continuous prolonged and generalized myoclonus) within 72 to 120 hours after ROSC predicted poor outcome, with a 0% FPR (95% CI, 0%–4%). However, some series report good neurologic recovery in which an early-onset and prolonged myoclonus evolved into a chronic action myoclonus (Lance-Adams syndrome).[118,121–123] Therefore, the presence of any myoclonus is not a reliable predictor of poor functional recovery, but status myoclonus during the first 72 hours after cardiac arrest achieved an FPR of 0% (95% CI, 0%–4%).

In patients not treated with TTM, status myoclonus on admission (FPR, 0%; 95% CI, 0%–5%)[124] at 24 hours after cardiac arrest[116] (FPR, 0%; 95% CI, 0%–7%) or within 72 hours of cardiac arrest[114,125] (FPR, 0%; 95% CI, 0%–14%) is associated with poor outcome. The older studies were less precise in distinguishing myoclonus from status myoclonus, lowering confidence in their estimated predictive value.

2015 Recommendations—New and Updated

In comatose patients who are not treated with TTM, the absence of pupillary reflex to light at 72 hours or more after cardiac arrest is a reasonable exam finding with which to predict poor neurologic outcome (FPR, 0%; 95% CI, 0%–8%; Class IIa, LOE B-NR).

In comatose patients who are treated with TTM, the absence of pupillary reflex to light at 72 hours or more after cardiac arrest is useful to predict poor neurologic outcome (FPR, 1%; 95% CI, 0%–3%; Class I, LOE B-NR).

We recommend that, given their unacceptable FPRs, the findings of either absent motor movements or extensor posturing *should not* be used alone for predicting a poor neurologic outcome (FPR, 10%; 95% CI, 7%–15% to FPR, 15%; 95% CI, 5%–31%; Class III: Harm, LOE B-NR). The motor examination may be a reasonable means to identify the population who need further prognostic testing to predict poor outcome (Class IIb, LOE B-NR).

We recommend that the presence of myoclonus, which is distinct from status myoclonus, *should not* be used to predict poor neurologic outcomes because of the high FPR (FPR, 5%; 95% CI, 3%–8% to FPR, 11%; 95% CI, 3%–26%; Class III: Harm, LOE B-NR).

In combination with other diagnostic tests at 72 or more hours after cardiac arrest, the presence of status myoclonus during the first 72 to 120 hours after cardiac arrest is a reasonable finding to help predict poor neurologic outcomes (FPR, 0%; 95% CI, 0%–4%; Class IIa, LOE B-NR).

EEG Findings to Predict Outcome[ALS 450, ALS 713]

EEG is a widely used tool to assess brain cortical activity and diagnose seizures. EEG is the standard tool used to assess brain electrical activity (ie, EEG rhythms) and paroxysmal activity (ie, seizures and bursts). While EEG has been used widely in the diagnosis of seizures and prognostication after cardiac arrest, the lack of standardized EEG terminology continues to be a major limitation in research and practice.[126]

2015 Evidence Summary

In patients treated with TTM, the 2015 ILCOR systematic review identified EEG with burst suppression, epileptiform activity, and reactivity as potential predictors of poor outcome. Two studies reported that burst suppression on initial EEG predicted poor outcome, with a 0% FPR (95% CI, 0%–5%),[127,128] but 2 other studies reported that EEG during TTM predicted poor outcome, with a 6% FPR (95% CI, 1%–15%).[111,129] Burst suppression after rewarming was associated with poor outcome[128] (FPR, 0%; 95% CI, 0%–5%). Some studies reported good outcome despite the presence of epileptiform discharges during TTM.[110,130] In several case series, no patients with electrographic seizures during or after TTM had good outcome,[78,110,130–132] but other studies reported cases with good outcome when seizures occurred in the presence of a reactive EEG background.[118,128] Absence of EEG reactivity during TTM predicted poor outcome, with an FPR of 2% (95% CI, 1%–7%),[78,111,119] and absence of EEG reactivity after rewarming predicted poor outcome, with an FPR of 0% (95% CI, 0%–3%).[78,110,111] Low-voltage EEG,[128] low bispectral index,[133] and EEG grades[78] were not reliably associated with poor outcome.

In patients not treated with TTM, the 2015 ILCOR systematic review identified EEG grades, burst suppression, and amplitude as potential predictors of poor outcome. EEG grades 4 to 5 at 72 hours or less after cardiac arrest predicted poor outcome, with a 0% FPR (95% CI, 0%–8%),[134–136] and burst suppression at 72 hours after cardiac arrest predicted poor outcome, with a 0% FPR (95% CI, 0%–11%).[114] EEG grades were not defined consistently between studies. Low-voltage EEG (≤20 to 21 μV) predicted poor outcome, with 0%

FPR (95% CI, 0%–5%) within 48 hours after cardiac arrest (1 study)[116] and with 0% FPR (95% CI, 0%–11%) at 72 hours after cardiac arrest.[114] However, low-voltage EEG is not reliable, because a variety of technical factors can affect EEG amplitude.

2015 Recommendations—Updated

In comatose post–cardiac arrest patients who are treated with TTM, it may be reasonable to consider persistent absence of EEG reactivity to external stimuli at 72 hours after cardiac arrest, and persistent burst suppression on EEG after rewarming, to predict a poor outcome (FPR, 0%; 95% CI, 0%–3%; Class IIb, LOE B-NR).

Intractable and persistent (more than 72 hours) status epilepticus in the absence of EEG reactivity to external stimuli may be reasonable to predict poor outcome (Class IIb, LOE B-NR).

In comatose post–cardiac arrest patients who are not treated with TTM, it may be reasonable to consider the presence of burst suppression on EEG at 72 hours or more after cardiac arrest, in combination with other predictors, to predict a poor neurologic outcome (FPR, 0%; 95% CI, 0%–11%; Class IIb, LOE B-NR).

Evoked Potentials to Predict Outcome[ALS 450, ALS 713]

The 2010 Guidelines advised that somatosensory evoked potentials (SSEPs) could be used as a prognostic tool in cardiac arrest survivors. The N20 waveform recorded from the primary cortical somatosensory area after median nerve stimulation was evaluated as a predictor of neurologic recovery in post–cardiac arrest patients.

2015 Evidence Summary

The 2015 systematic review found that in patients who are comatose after resuscitation from cardiac arrest and who are treated with TTM, bilaterally absent N20 was highly predictive of poor outcome. Absent N20 during TTM predicted poor outcome, with a 2% FPR (95% CI, 0%–4%).[104,129,137,138] Absent N20 after rewarming predicted poor outcome, with a 1% FPR (95% CI, 0%–3%).[104–106,108,110–112,119,139,140] One caution about these data is that SSEP has been used by healthcare providers and families as the parameter for withdrawal of life-sustaining therapies both in studies[103] and in bedside care, a practice that may inflate the apparent predictive accuracy of the test.

In patients not treated with TTM, bilateral absence of the N20 predicts poor outcome at 24, 48, or 72 hours after cardiac arrest (FPR, 0%; 95% CI, 0%–3% and 0%–12%).[115,138,141–149] Only 1 case of a false-positive result from absent SSEP in a patient not treated with TTM was identified.[116] Again, these studies may have allowed treating teams to act on the results of the SSEP, potentially inflating the accuracy of this test.

2015 Recommendations—Updated

In patients who are comatose after resuscitation from cardiac arrest regardless of treatment with TTM, it is reasonable to consider bilateral absence of the N20 SSEP wave 24 to 72 hours after cardiac arrest or after rewarming a predictor of poor outcome (FPR, 1%; 95% CI, 0%–3%; Class IIa, LOE B-NR).

SSEP recording requires appropriate skills and experience, and utmost care should be taken to avoid electrical interference from muscle artifacts or from the intensive care unit environment. However, sedative drugs or temperature manipulation affect SSEPs less than they affect the EEG or clinical examination.[138,150]

Imaging Tests to Predict Outcome[ALS 450, ALS 713]

Previous guidelines did not suggest specific imaging tests for prognosis in post–cardiac arrest coma. Brain imaging studies, including computed tomography (CT) or magnetic resonance imaging (MRI) can define structural brain injury or detect focal injury. On brain CT, some post–cardiac arrest patients exhibit brain edema, which can be quantified as the gray-white ratio (GWR), defined as the ratio between the x-ray attenuation measured in Hounsfield units of the gray matter and the white matter. Normal brain has GWR around 1.3, and this number decreases with edema.[105] Brain edema on MRI is a sensitive marker of focal injury and is detected by restricted diffusion on diffusion-weighted imaging (DWI) sequences[151] and can be quantified by using apparent diffusion coefficient (ADC). Normal ADC values range between 700 and 800 × 10^{-6} mm^2/s and decrease with edema.[152]

2015 Evidence Summary

The 2015 ILCOR systematic review identified 4 studies of CT scan performed within 2 hours after cardiac arrest in patients treated with TTM. A reduced GWR at the level of the basal ganglia on brain CT predicted poor outcome, with FPR ranging from 0% to 8%.[105,153–155] Measurement techniques and thresholds for GWR varied among studies. Global cerebral edema on brain CT at a median of 1 day after cardiac arrest also predicted poor outcome[107] (FPR, 0%; 95% CI, 0%–5%).

The 2015 ILCOR systematic review found 3 studies of CT scan on patients not treated with TTM. At 72 hours after cardiac arrest, the presence of diffuse brain swelling on CT predicted a poor outcome, with a 0% FPR (95% CI, 0%–45%).[156] In 2 studies, a GWR between the caudate nucleus and the posterior limb of internal capsule below 1.22 within 24 hours (FPR, 0%; 95% CI, 0%–28%) or below 1.18 within 48 hours (FPR, 17%; 95% CI, 0%–64%) after cardiac arrest predicted poor outcome.[157,158]

In patients treated with TTM, the 2015 systematic review identified two studies relating MRI findings to outcome. Presence of more than 10% of brain volume with ADC less than 650 × 10^{-6} mm^2/s predicted poor outcome[159] (FPR, 0%; 95% CI, 0%–78%). Low ADC at the level of putamen, thalamus, or occipital cortex predicted poor outcome, with 0% FPR[160] (95% CIs, from 0%–24%), although the ADC threshold in each region varied.

In patients not treated with TTM, 6 studies related MRI findings to poor outcome. Diffuse DWI abnormalities in cortex or brainstem at a median of 80 hours after cardiac arrest predicted poor outcome, with a 0% FPR (95% CI, 0%–35%).[151] Extensive (cortex, basal ganglia, and cerebellum) DWI changes predicted poor outcome, with a 0% FPR (95% CI, 0%–45%).[161] Whole-brain ADC less than 665 × 10^{-6} mm^2/s predicted poor outcome, with 0% FPR (95% CI, 0%–21%).[162] More than 10% of brain volume with ADC less than 650 × 10^{-6} mm^2/s predicted

poor outcome, with 0% FPR (95% CI, 0%–28%).[159] ADC below various thresholds at the level of putamen, thalamus, or occipital cortex at less than 120 hours after cardiac arrest predicted poor outcome, with 0% FPR (95% CI, 0%–31%). The presence of extensive cortical global DWI or fluid-attenuated inversion recovery changes within 7 days from arrest-predicted poor outcome, with a 0% FPR (95% CI, 0%–78%).[117,152]

MRI testing may be difficult in unstable patients, which may lead to selection bias. Studies report that DWI changes are most apparent more than 48 hours after cardiac arrest,[159] with most studies examining patients 3 to 7 days after cardiac arrest.

2015 Recommendations—New

In patients who are comatose after resuscitation from cardiac arrest and not treated with TTM, it may be reasonable to use the presence of a marked reduction of the GWR on brain CT obtained within 2 hours after cardiac arrest to predict poor outcome (Class IIb, LOE B-NR).

It may be reasonable to consider extensive restriction of diffusion on brain MRI at 2 to 6 days after cardiac arrest in combination with other established predictors to predict a poor neurologic outcome (Class IIb, LOE B-NR).

Acquisition and interpretation of imaging studies have not been fully standardized and are subject to interobserver variability.[163] In addition, the recommendations for brain imaging studies for prognostication are made with the assumption that images are performed in centers with expertise in this area.

Blood Markers to Predict Outcome[ALS 450, ALS 713]

Many blood markers have been examined for the prognostication of post–cardiac arrest patients. In 2015, the ILCOR Advanced Life Support Task Force evaluated whether blood markers can be used alone or in conjunction with other neurologic testing to prognosticate outcome in postarrest patients.

2015 Evidence Summary

The 2015 ILCOR systematic review examined many studies of blood markers to predict neurologic outcomes at various times after cardiac arrest, both in patients treated and not treated with TTM.[104,106–108,111,114,119,132,133,145,147,155,160,164–176] Neuron-specific enolase (NSE) and S-100B are the 2 most commonly examined blood markers.

Studies of NSE and S-100B reported that initial S-100B levels were higher in patients with poor outcome compared to patients with good outcome, and that NSE levels would increase over 72 hours in patients with poor outcome relative to patients with good outcome. However, studies did not identify specific blood levels of these proteins that enable prediction of poor neurologic outcome with perfect specificity and narrow confidence intervals. Therefore, no threshold values that enable prediction of poor outcome with confidence were identified.

2015 Recommendations—Updated

Given the possibility of high FPRs, blood levels of NSE and S-100B **should not** be used alone to predict a poor neurologic outcome (Class III: Harm, LOE C-LD).

When performed with other prognostic tests at 72 hours or more after cardiac arrest, it may be reasonable to consider high serum values of NSE at 48 to 72 hours after cardiac arrest to support the prognosis of a poor neurologic outcome (Class IIb, LOE B-NR), especially if repeated sampling reveals persistently high values (Class IIb, LOE C-LD).

Laboratory standards for NSE and S-100B measurement vary between centers, making comparison of absolute values difficult. The kinetics of these markers have not been studied, particularly during or after TTM in cardiac arrest patients. Finally, NSE and S-100B are not specific to neuronal damage and can be produced by extra–central nervous system sources (hemolysis, neuroendocrine tumors, myenteric plexus, muscle, and adipose tissue breakdown). If care is not taken when drawing NSE levels and if multiple time points are not assessed, false-positive results could occur secondary to hemolysis. All of these limitations led the writing group to conclude that NSE should be limited to a confirmatory test rather than a primary method for estimating prognosis.

Organ Donation[ALS 449]

The 2010 Guidelines emphasized that adult patients who progress to brain death after resuscitation from cardiac arrest should be considered as potential organ donors.

2015 Evidence Summary

The 2015 ILCOR systematic reviews considered the success rate of transplants when organs are taken from adult and pediatric donors who progressed to death or brain death after cardiac arrest. Post–cardiac arrest patients are an increasing proportion of the pool of organ donors.[177] When patients who have previously had cardiopulmonary resuscitation proceed to become organ donors, each donor provides a mean of 3.9[178] or 2.9[177] organs. Multiple studies found no difference in immediate or long-term function of organs from donors who reach brain death after cardiac arrest when compared with donors who reach brain death from other causes. In addition, some patients have withdrawal of life support after cardiac arrest as a consequence of failure to improve neurologically or as part of advanced directives, which can lead to cardiovascular death in a predictable time frame that may allow donation of kidney or liver. Organs transplanted from these donors also have success rates comparable to similar donors with other conditions. These studies examined adult hearts,[177,179–185] pediatric hearts,[177,186–189] adult lungs,[177,183,190] pediatric lungs,[177] adult kidneys,[177,191] pediatric kidneys,[177,188] adult livers,[177,179] pediatric livers,[177,188] adult intestines,[177,192] and pediatric intestines.[177] Finally, tissue donation (cornea, skin, and bone) is almost always possible if post–cardiac arrest patients die.

A few programs have developed procedures for recovery of kidney and liver when return of pulses cannot be achieved. Existing programs rely on continued mechanical circulatory support and very rapid mobilization of surgeons and transplant teams after a patient is unexpectedly pronounced dead. The resources to accomplish these donations require significant institutional preparation. These programs also require careful and thoughtful safeguards to prevent donation efforts from interfering with ongoing resuscitation efforts. A mean of 1.5[193] or 3.2[194] organs were procured from each donor in these programs. Function of adult kidneys[195–197] or adult livers[193,196,198] from these donors was similar immediately, 1 year, and 5 years after transplantation.

2015 Recommendations—Updated and New

We recommend that all patients who are resuscitated from cardiac arrest but who subsequently progress to death or brain death be evaluated for organ donation (Class I, LOE B-NR).

Patients who do not have ROSC after resuscitation efforts and who would otherwise have termination of efforts may be considered candidates for kidney or liver donation in settings where programs exist (Class IIb, LOE B-NR). The ethics and practical aspects of these programs are quite complex and beyond the scope of this review.

Conclusions and Future Directions

The field of post–cardiac arrest care has increased in rigor and depth over the past decade. Investigations over this period illustrate the heterogeneity of patients hospitalized after cardiac arrest in terms of etiology, comorbid disease, and illness severity. Future interventional trials should ideally be designed to take into account patient heterogeneity and focus interventions on the specific subgroups most likely to benefit. By tailoring interventions to patient physiology and disease, a greater chance exists that the right therapies will be matched to the patients who will benefit.

Disclosures

Part 8: Post–Cardiac Arrest Care: 2015 Guidelines Update Writing Group Disclosures

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This table represents the relationships of writing group members that may be perceived as actual or reasonably perceived conflicts of interest as reported on the Disclosure Questionnaire, which all members of the writing group are required to complete and submit. A relationship is considered to be "significant" if (a) the person receives $10 000 or more during any 12-month period, or 5% or more of the person's gross income; or (b) the person owns 5% or more of the voting stock or share of the entity, or owns $10 000 or more of the fair market value of the entity. A relationship is considered to be "modest" if it is less than "significant" under the preceding definition.

*Modest.

†Significant.

Appendix

2015 Guidelines Update: Part 8 Recommendations

Year Last Reviewed	Topic	Recommendation	Comments
2015	Cardiovascular Care	Coronary angiography should be performed emergently (rather than later in the hospital stay or not at all) for OHCA patients with suspected cardiac etiology of arrest and ST elevation on ECG (Class I, LOE B-NR).	updated for 2015
2015	Cardiovascular Care	Emergent coronary angiography is reasonable for select (e.g. electrically or hemodynamically unstable) adult patients who are comatose after OHCA of suspected cardiac origin but without ST elevation on ECG (Class IIa, LOE B-NR).	updated for 2015
2015	Cardiovascular Care	Coronary angiography is reasonable in post–cardiac arrest patients for whom coronary angiography is indicated regardless of whether the patient is comatose or awake (Class IIa, LOE C-LD).	updated for 2015
2015	Hemodynamic Goals	Avoiding and immediately correcting hypotension (systolic blood pressure less than 90 mm Hg, MAP less than 65 mm Hg) during postresuscitation care may be reasonable (Class IIb, LOE C-LD).	new for 2015
2015	Targeted Temperature Management	We recommend that comatose (ie, lack of meaningful response to verbal commands) adult patients with ROSC after cardiac arrest have TTM (Class I, LOE B-R for VF/pVT OHCA; Class I, LOE C-EO for non-VF/pVT (ie, "nonshockable") and in-hospital cardiac arrest).	updated for 2015
2015	Targeted Temperature Management	We recommend selecting and maintaining a constant temperature between 32ºC and 36ºC during TTM (Class I, LOE B-R).	updated for 2015
2015	Targeted Temperature Management	It is reasonable that TTM be maintained for at least 24 hours after achieving target temperature (Class IIa, LOE C-EO).	updated for 2015
2015	Targeted Temperature Management	We recommend against the routine prehospital cooling of patients after ROSC with rapid infusion of cold intravenous fluids (Class III: No Benefit, LOE A).	new for 2015
2015	Targeted Temperature Management	It may be reasonable to actively prevent fever in comatose patients after TTM (Class IIb, LOE C-LD).	new for 2015
2015	Other Neurologic Care	An EEG for the diagnosis of seizure should be promptly performed and interpreted, and then should be monitored frequently or continuously in comatose patients after ROSC (Class I, LOE C-LD).	updated for 2015
2015	Other Neurologic Care	The same anticonvulsant regimens for the treatment of status epilepticus caused by other etiologies may be considered after cardiac arrest (Class IIb, LOE C-LD).	updated for 2015
2015	Respiratory Care	Maintaining the $Paco_2$ within a normal physiological range, taking into account any temperature correction, may be reasonable (Class IIb, LOE B-NR).	updated for 2015
2015	Respiratory Care	To avoid hypoxia in adults with ROSC after cardiac arrest, it is reasonable to use the highest available oxygen concentration until the arterial oxyhemoglobin saturation or the partial pressure of arterial oxygen can be measured (Class IIa, LOE C-EO).	new for 2015
2015	Respiratory Care	When resources are available to titrate the Fio_2 and to monitor oxyhemoglobin saturation, it is reasonable to decrease the Fio_2 when oxyhemoglobin saturation is 100%, provided the oxyhemoglobin saturation can be maintained at 94% or greater (Class IIa, LOE C-LD).	updated for 2015
2015	Other Critical Care Interventions	The benefit of any specific target range of glucose management is uncertain in adults with ROSC after cardiac arrest (Class IIb, LOE B-R).	updated for 2015
2015	Prognostication of Outcome	The earliest time for prognostication using clinical examination in patients treated with TTM, where sedation or paralysis could be a confounder, may be 72 hours after normothermia (Class IIb, LOE C-EO).	updated for 2015
2015	Other Critical Care Interventions	We recommend the earliest time to prognosticate a poor neurologic outcome using clinical examination in patients not treated with TTM is 72 hours after cardiac arrest (Class I, LOE B-NR).	new for 2015
2015	Other Critical Care Interventions	This time until prognostication can be even longer than 72 hours after cardiac arrest if the residual effect of sedation or paralysis confounds the clinical examination (Class IIa, LOE C-LD).	new for 2015
2015	Other Critical Care Interventions	In comatose patients who are not treated with TTM, the absence of pupillary reflex to light at 72 hours or more after cardiac arrest is a reasonable exam finding with which to predict poor neurologic outcome (FPR, 0%; 95% CI, 0%–8%; Class IIa, LOE B-NR).	new for 2015
2015	Other Critical Care Interventions	In comatose patients who are treated with TTM, the absence of pupillary reflex to light at 72 hours or more after cardiac arrest is useful to predict poor neurologic outcome (FPR, 1%; 95% CI, 0%–3%; Class I, LOE B-NR).	new for 2015
2015	Other Critical Care Interventions	We recommend that, given their unacceptable FPRs, the findings of either absent motor movements or extensor posturing should not be used alone for predicting a poor neurologic outcome (FPR, 10%; 95% CI, 7%–15% to FPR, 15%; 95% CI, 5%–31%; Class III: Harm, LOE B-NR).	new for 2015
2015	Other Critical Care Interventions	The motor examination may be a reasonable means to identify the population who need further prognostic testing to predict poor outcome (Class IIb, LOE B-NR).	new for 2015
2015	Other Critical Care Interventions	We recommend that the presence of myoclonus, which is distinct from status myoclonus, should not be used to predict poor neurologic outcomes because of the high FPR (FPR, 5%; 95% CI, 3%–8% to FPR, 11%; 95% CI, 3%–26%; Class III: Harm, LOE B-NR).	updated for 2015

(*Continued*)

2015 Guidelines Update: Part 8 Recommendations, *Continued*

Year Last Reviewed	Topic	Recommendation	Comments
2015	Other Critical Care Interventions	In combination with other diagnostic tests at 72 or more hours after cardiac arrest, the presence of status myoclonus during the first 72 to 120 hours after cardiac arrest is a reasonable finding to help predict poor neurologic outcomes (FPR, 0%; 95% CI, 0%–4%; Class IIa, LOE B-NR).	new for 2015
2015	Other Critical Care Interventions	In comatose post–cardiac arrest patients who are treated with TTM, it may be reasonable to consider persistent absence of EEG reactivity to external stimuli at 72 hours after cardiac arrest, and persistent burst suppression on EEG after rewarming, to predict a poor outcome (FPR, 0%; 95% CI, 0%–3%; Class IIb, LOE B-NR).	updated for 2015
2015	Other Critical Care Interventions	Intractable and persistent (more than 72 hours) status epilepticus in the absence of EEG reactivity to external stimuli may be reasonable to predict poor outcome (Class IIb, LOE B-NR).	updated for 2015
2015	Other Critical Care Interventions	In comatose post–cardiac arrest patients who are not treated with TTM, it may be reasonable to consider the presence of burst suppression on EEG at 72 hours or more after cardiac arrest, in combination with other predictors, to predict a poor neurologic outcome (FPR, 0%; 95% CI, 0%–11%; Class IIb, LOE B-NR).	updated for 2015
2015	Other Critical Care Interventions	In patients who are comatose after resuscitation from cardiac arrest regardless of treatment with TTM, it is reasonable to consider bilateral absence of the N20 SSEP wave 24 to 72 hours after cardiac arrest or after rewarming a predictor of poor outcome (FPR, 1%; 95% CI, 0%–3%; Class IIa, LOE B-NR).	updated for 2015
2015	Other Critical Care Interventions	In patients who are comatose after resuscitation from cardiac arrest and not treated with TTM, it may be reasonable to use the presence of a marked reduction of the GWR on brain CT obtained within 2 hours after cardiac arrest to predict poor outcome (Class IIb, LOE B-NR).	new for 2015
2015	Other Critical Care Interventions	It may be reasonable to consider extensive restriction of diffusion on brain MRI at 2 to 6 days after cardiac arrest in combination with other established predictors to predict a poor neurologic outcome (Class IIb, LOE B-NR).	new for 2015
2015	Other Critical Care Interventions	Given the possibility of high FPRs, blood levels of NSE and S-100B should not be used alone to predict a poor neurologic outcome (Class III: Harm, LOE C-LD).	updated for 2015
2015	Other Critical Care Interventions	When performed with other prognostic tests at 72 hours or more after cardiac arrest, it may be reasonable to consider high serum values of NSE at 48 to 72 hours after cardiac arrest to support the prognosis of a poor neurologic outcome (Class IIb, LOE B-NR), especially if repeated sampling reveals persistently high values (Class IIb, LOE C-LD).	updated for 2015
2015	Other Critical Care Interventions	We recommend that all patients who are resuscitated from cardiac arrest but who subsequently progress to death or brain death be evaluated for organ donation (Class I, LOE B-NR).	updated for 2015
2015	Other Critical Care Interventions	Patients who do not have ROSC after resuscitation efforts and who would otherwise have termination of efforts may be considered candidates for kidney or liver donation in settings where programs exist (Class IIb, LOE B-NR).	new for 2015
The following recommendations were not reviewed in 2015. For more information, see the *2010 AHA Guidelines for CPR and ECC*, "Part 9: Post–Cardiac Arrest Care."			
2010	Systems of Care for Improving Post–Cardiac Arrest Outcomes	A comprehensive, structured, multidisciplinary system of care should be implemented in a consistent manner for the treatment of post–cardiac arrest patients (Class I, LOE B).	not reviewed in 2015
2010	Treatment of Pulmonary Embolism After CPR	In post–cardiac arrest patients with arrest due to presumed or known pulmonary embolism, fibrinolytics may be considered (Class IIb, LOE C).	not reviewed in 2015
2010	Sedation After Cardiac Arrest	It is reasonable to consider the titrated use of sedation and analgesia in critically ill patients who require mechanical ventilation or shivering suppression during induced hypothermia after cardiac arrest (Class IIb, LOE C).	not reviewed in 2015
2010	Cardiovascular System	A 12-lead ECG should be obtained as soon as possible after ROSC to determine whether acute ST elevation is present (Class I, LOE B).	not reviewed in 2015
2010	Neuroprotective Drugs	The routine use of coenzyme Q10 in patients treated with hypothermia is uncertain (Class IIb, LOE B).	not reviewed in 2015
2010	Evoked Potentials	Bilateral absence of the N20 cortical response to median nerve stimulation after 24 hours predicts poor outcome in comatose cardiac arrest survivors not treated with therapeutic hypothermia (Class IIa, LOE A).	not reviewed in 2015

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