Part 8: Post-Cardiac Arrest Care

Web-based Integrated 2010 & 2015 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care

Key Words: cardiac arrest drug imaging moderate hypothermia

1 Highlights

Summary of Key Issues and Major Changes

Key issues and major changes in the 2015 Guidelines Update recommendations for post–cardiac arrest care include the following:

- Emergency coronary angiography is recommended for all patients with ST elevation and for hemodynamically or electrically unstable patients without ST elevation for whom a cardiovascular lesion is suspected.
- TTM recommendations have been updated with new evidence suggesting that a range of temperatures may be acceptable to target in the post–cardiac arrest period.
- After TTM is complete, fever may develop. While there are conflicting observational data about the harm of fever after TTM, the prevention of fever is considered benign and therefore is reasonable to pursue.
- Identification and correction of hypotension is recommended in the immediate post–cardiac arrest period.
- Prognostication is now recommended no sooner than 72 hours after the completion of TTM; for those who do not have TTM, prognostication is not recommended any sooner than 72 hours after ROSC.
- All patients who progress to brain death or circulatory death after initial cardiac arrest should be considered potential organ donors.

Coronary Angiography

2015 (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. 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. Coronary angiography is reasonable in post–cardiac arrest patients for whom coronary angiography is indicated, regardless of whether the patient is comatose or awake.

2010 (Old): Primary PCI (PPCI) after ROSC in subjects with arrest of presumed ischemic cardiac etiology may be reasonable, even in the absence of a clearly defined STEMI. Appropriate treatment of acute coronary syndromes (ACS) or STEMI, including PCI or fibrinolysis, should be initiated regardless of coma.

Why: Multiple observational studies found positive associations between emergency coronary revascularization and both survival and favorable functional outcome. In the absence of cardiac arrest, guidelines already recommend emergency treatment of STEMI and emergency treatment of non–ST-segment elevation ACS with electrical or hemodynamic instability. Because the outcome of coma may be improved by correction of cardiac instability, and the prognosis of coma cannot be reliably determined in the first few hours after cardiac arrest, emergency treatment of post–cardiac arrest patients should follow identical guidelines.

Targeted Temperature Management

2015 (Updated): All comatose (ie, lacking meaningful response to verbal commands) adult patients with ROSC after cardiac arrest should have TTM, with a target temperature between 32°C and 36°C selected and achieved, then maintained constantly for at least 24 hours.

2010 (Old): Comatose (ie, lacking of meaningful response to verbal commands) adult patients with ROSC after out-of-hospital VF cardiac arrest should be cooled to 32°C to 34°C for 12 to 24 hours. Induced hypothermia also may be considered for comatose adult patients with ROSC after IHCA of any initial rhythm or after OHCA with an initial rhythm of pulseless electrical activity or asystole.

Why: Initial studies of TTM examined cooling to temperatures between 32°C and 34°C compared with no well-defined TTM and found improvement in neurologic outcome for those in whom hypothermia was induced. A recent high-quality study compared temperature management at 36°C and at 33°C and found outcomes to be similar for both. Taken together, the initial studies suggest that TTM is beneficial, so the recommendation remains to select a single target temperature and perform TTM. Given that 33°C is no better than 36°C, clinicians can select from a wider range of target temperatures. The selected temperature may be determined by clinician preference or clinical factors.

Continuing Temperature Management Beyond 24 Hours

2015 (New): Actively preventing fever in comatose patients after TTM is reasonable.

Why: In some observational studies, fever after rewarming from TTM is associated with worsened neurologic injury, although studies are conflicting. Because preventing fever after TTM is relatively benign and fever may be associated with harm, preventing fever is suggested.

Out-of-Hospital Cooling

2015 (New): The routine prehospital cooling of patients with rapid infusion of cold IV fluids after ROSC is not recommended.

Why: Before 2010, cooling patients in the prehospital setting had not been extensively evaluated. It had been assumed that earlier initiation of cooling might provide added benefits and also that prehospital initiation might facilitate and encourage continued in-hospital cooling. Recently published high-quality studies demonstrated no benefit to prehospital cooling and also identified potential complications when using cold IV fluids for prehospital cooling.

Hemodynamic Goals After Resuscitation

2015 (New): It may be reasonable to avoid and immediately correct hypotension (systolic blood pressure less than 90 mm Hg, mean arterial pressure less than 65 mm Hg) during post–cardiac arrest care.

Why: Studies of patients after cardiac arrest have found that a systolic blood pressure less than 90 mm Hg or a mean arterial pressure of less than 65 mm Hg is associated with higher mortality and diminished functional recovery, while systolic arterial pressures of greater than 100 mm Hg are associated with better recovery. While higher pressures appear superior, specific systolic or mean arterial pressure targets could not be identified, because trials typically studied a bundle of many interventions, including hemodynamic control. Also, because baseline blood pressure varies from patient to patient, different patients may have different requirements to maintain optimal organ perfusion.

Prognostication After Cardiac Arrest

2015 (New): The earliest time to prognosticate a poor neurologic outcome using clinical examination in patients *not* treated with TTM is 72 hours after cardiac arrest, but this time can be even longer after cardiac arrest if the residual effect of sedation or paralysis is suspected to confound the clinical examination.

2015 (Updated): In patients treated *with* TTM, where sedation or paralysis could confound clinical examination, it is reasonable to wait until 72 hours after return to normothermia before predicting outcome.

2010 (Old): While times for usefulness of specific tests were identified, no specific overall recommendation was made about time to prognostication.

Why: Clinical findings, electrophysiologic modalities, imaging modalities, and blood markers are all useful for predicting neurologic outcome in comatose patients, but each finding, test, and marker is affected differently by sedation and neuromuscular blockade. In addition, the comatose brain may be more sensitive to medications, and medications may take longer to metabolize after cardiac arrest.

No single physical finding or test can predict neurologic recovery after cardiac arrest with 100% certainty. Multiple modalities of testing and examination used together to predict outcome after the effects of hypothermia and medications have been allowed to resolve, are most likely to provide accurate prediction of outcome (**Box 1**).

Box 1

Useful Clinical Findings That Are Associated With Poor Neurologic Outcome*

- Absence of pupillary reflex to light at 72 hours or more after cardiac arrest
- Presence of status myoclonus (different from isolated myoclonic jerks) during the first 72 hours after cardiac arrest
- Absence of the N20 somatosensory evoked potential cortical wave 24 to 72 hours after cardiac arrest or after rewarming
- Presence of a marked reduction of the gray-white ratio on brain CT obtained within 2 hours after cardiac arrest
- Extensive restriction of diffusion on brain MRI at 2 to 6 days after cardiac arrest
- Persistent absence of EEG reactivity to external stimuli at 72 hours after cardiac arrest
- Persistent burst suppression or intractable status epilepticus on EEG after rewarming

Absent motor movements, extensor posturing, or myoclonus should not be used alone for predicting outcome.

*Shock, temperature, metabolic derangement, prior sedatives or neuromuscular blockers, and other clinical factors should be considered carefully because they may affect results or interpretation of some tests.

Abbreviations: CT, computed tomography; EEG, electroencephalogram; MRI, magnetic resonance imaging.

Organ Donation

2015 (Updated): All patients who are resuscitated from cardiac arrest but who subsequently progress to death or brain death should be evaluated as potential organ donors. Patients who do not achieve ROSC and who would otherwise have resuscitation terminated may be considered as potential kidney or liver donors in settings where rapid organ recovery programs exist.

2010 (Old): Adult patients who progress to brain death after resuscitation from cardiac arrest should be considered for organ donation.

Why: There has been no difference reported 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. Organs transplanted from these donors have success rates comparable to organs recovered from similar donors with other conditions.

2 Introduction - Updated

These Web-based Integrated Guidelines incorporate the relevant recommendations from 2010 and the new or updated recommendations from 2015.

The recommendations in the *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] and was completed in February 2015.[2,3]

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,[4] 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.[5]

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 the 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.

The 2015 recommendations use 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 the 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."

2.1 Systems of Care for Improving Post–Cardiac Arrest Outcomes

Post–cardiac arrest care is a critical component of advanced life support (Figure 1). Most deaths occur during the first 24 hours after cardiac arrest.[6,7] The best hospital care for patients with ROSC after cardiac arrest is not completely known, but there is increasing interest in identifying and optimizing practices that are likely to improve outcomes (Table 1).[8] Positive associations have been noted between the likelihood of survival and the number of cardiac arrest cases treated at any individual hospital.[9,10] Because multiple organ systems are affected after cardiac arrest, successful post–cardiac arrest care will benefit from the development of system-wide plans for proactive treatment of these patients. For example, restoration of blood pressure and gas exchange does not ensure survival and functional recovery. Significant cardiovascular dysfunction can develop, requiring support of blood flow and ventilation, including intravascular volume expansion, vasoactive and inotropic drugs, and invasive devices. Therapeutic hypothermia and treatment of the underlying cause of cardiac arrest impacts survival and neurological outcomes. Protocolized hemodynamic optimization and multidisciplinary early goal-directed therapy protocols have been introduced as part of a bundle of care to improve survival rather than single interventions.[11-13] The data suggests that proactive titration of post–cardiac arrest hemodynamics to levels intended to ensure organ perfusion and oxygenation may improve outcomes. There are multiple specific options

for achieving these goals, and it is difficult to distinguish between the benefit of protocols or any specific component of care that is most important.

Figure 1: Adult Immediate Post–Cardiac Arrest Care Algorithm - 2015 Update

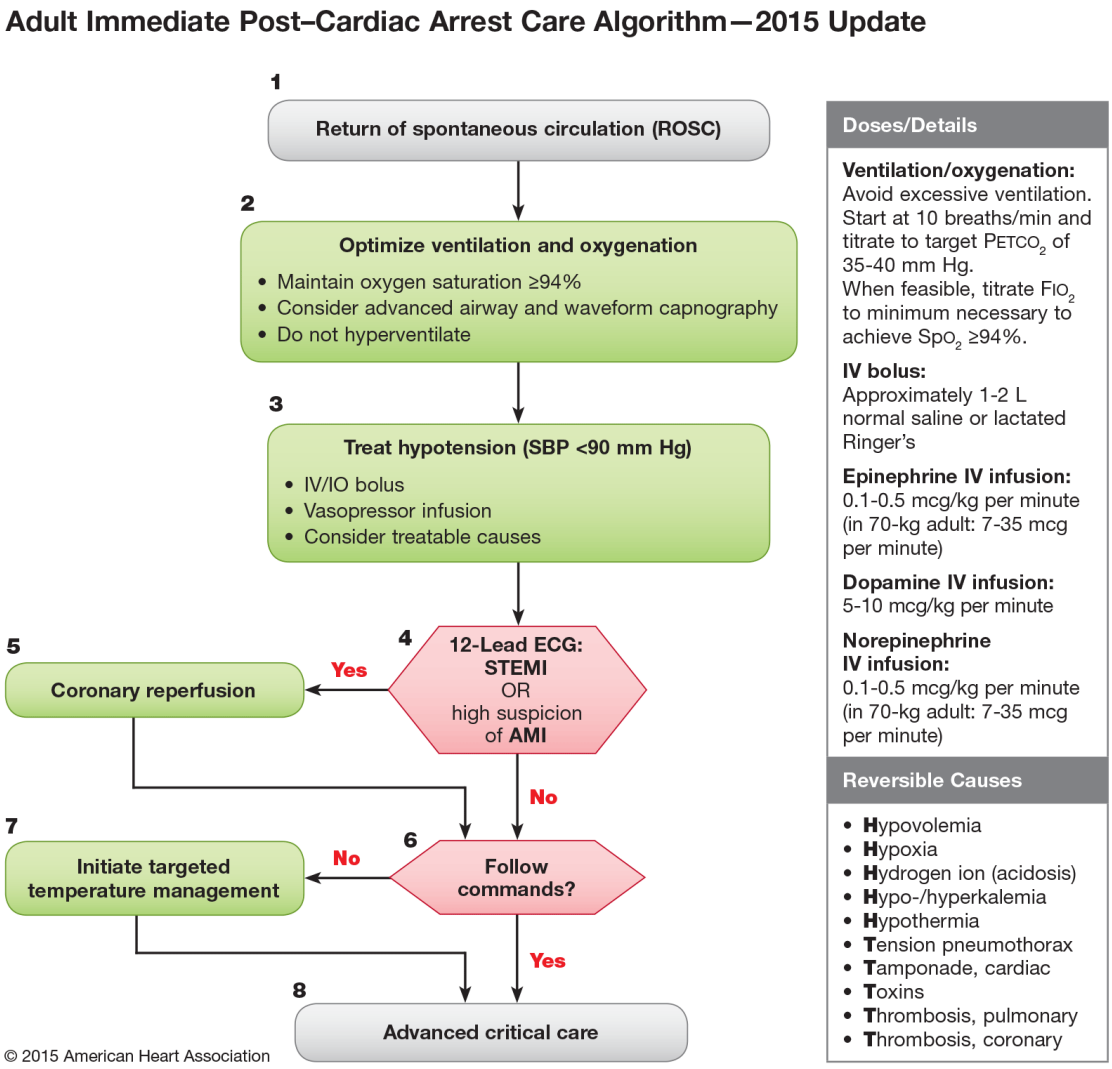

Table 1: 2010 - Multiple System Approach to Post–Cardiac Arrest Care

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Multiple System Approach to Post–Cardiac Arrest Care				
Ventilation	**Hemodynamics**	**Cardiovascular**	**Neurological**	**Metabolic**

• Capnography ◦ Rationale: Confirm secure airway and titrate ventilation ◦ Endotracheal tube when possible for comatose patients ◦ $Petco_2$?35–40 mm Hg ◦ $Paco_2$?40–45 mm Hg	• Frequent Blood Pressure Monitoring/Arterial-line ◦ Rationale: Maintain perfusion and prevent recurrent hypotension ◦ Mean arterial pressure ?65 mm Hg or systolic blood pressure ?90 mm Hg	• Continuous Cardiac Monitoring ◦ Rationale: Detect recurrent arrhythmia ◦ No prophylactic antiarrhythmics ◦ Treat arrhythmias as required ◦ Remove reversible causes	• Serial Neurological Exam ◦ Rationale: Serial examinations define coma, brain injury, and prognosis ◦ Response to verbal commands or physical stimulation ◦ Pupillary light and corneal reflex, spontaneous eye movement ◦ Gag, cough, spontaneous breaths	• Serial Lactate ◦ Rationale: Confirm adequate perfusion

• Chest X-ray ○ Rationale: Confirm secure airway and detect causes or complications of arrest: pneumonia, pneumothorax, pulmonary edema	• Treat Hypotension ○ Rationale: Maintain perfusion ○ Fluid bolus if tolerated ○ Dopamine 5–10 mcg/kg per min ○ Norepinephrine 0.1–0.5 mcg/kg per min ○ Epinephrine 0.1–0.5 mcg/kg per min	• 12-lead ECG/Troponin ○ Rationale: Detect Acute Coronary Syndrome, ST-Elevation Myocardial Infarction, Assess QT interval	• EEG Monitoring If Comatose ○ Rationale: Exclude seizures ○ Anticonvulsants if seizing	• Serum Potassium ○ Rationale: Avoid hypokalemia which promotes arrhythmias ○ Replace to maintain K >3.5 mEq/L

• Pulse Oximetry/ABG ◦ Rationale: Maintain adequate oxygenation and minimize FiO_2 ◦ SpO_2 ?94% ◦ PaO_2 ?100 mm Hg ◦ Reduce FiO_2 as tolerated ◦ PaO_2/FiO_2 ratio to follow acute lung injury	…	• Treat Acute Coronary Syndrome ◦ Aspirin/heparin ◦ Transfer to acute coronary treatment center ◦ Consider emergent PCI or fibrinolysis	• Core Temperature Measurement If Comatose ◦ Rationale: Minimize brain injury and improve outcome ◦ Prevent hyperpyrexia >37.7°C ◦ Induce therapeutic hypothermia if no contraindications ◦ Cold IV fluid bolus 30 mL/kg if no contraindication ◦ Surface or endovascular cooling for 32°C–34°C×24 hours ◦ After 24 hours, slow rewarming 0.25°C/hr	• Urine Output, Serum Creatinine ◦ Rationale: Detect acute kidney injury ◦ Maintain euvolemia ◦ Renal replacement therapy if indicated

• Mechanical Ventilation ◦ Rationale: Minimize acute lung injury, potential oxygen toxicity ◦ Tidal Volume 6–8 mL/kg ◦ Titrate minute ventilation to P_{etCO_2} ?35–40 mm Hg $Paco_2$?40–45 mm Hg ◦ Reduce Fio_2 as tolerated to keep Spo_2 or Sao_2 ?94%	…	• Echocardiogram ◦ Rationale: Detect global stunning, wall-motion abnormalities, structural problems, or cardiomyopathy	• Consider Non-enhanced CT Scan ◦ Rationale: Exclude primary intracranial process	• Serum Glucose ◦ Rationale: Detect hyperglycemia and hypoglycemia ◦ Treat hypoglycemia (<80 mg/dL) with dextrose ◦ Treat hyperglycemia to target glucose 144–180 mg/dL ◦ Local insulin protocols

	…	• Treat Myocardial Stunning ○ Fluids to optimize volume status (requires clinical judgment) ○ Dobutamine 5–10 mcg/kg per min ○ Mechanical augmentation (IABP)	• Sedation/Muscle Relaxation ○ Rationale: To control shivering, agitation, or ventilator desynchrony as needed	• Avoid Hypotonic Fluids ○ Rationale: May increase edema, including cerebral edema

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)

Programs should include as part of structured interventions therapeutic hypothermia; optimization of hemodynamics and gas exchange; immediate coronary reperfusion when indicated for restoration of coronary blood flow with percutaneous coronary intervention (PCI); glycemic control; and neurological diagnosis, management, and prognostication.

2.2 Overview of Post-Cardiac Arrest Care - Updated

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.[14] 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.

3 Cardiovascular Care - Updated

3.1 Acute Cardiovascular Interventions - Updated 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 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[15-17] 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.[17]

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

3.1.1 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.[18-32] Nine observational studies showed improved neurologically favorable outcome associated with emergency coronary angiography in patients with ST elevation after cardiac arrest.[18-20,23,25-28,30]

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.[18,23]

3.1.2 Recommendations - Updated

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)

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.[33] 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.[34] 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.[33,35] 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.[36] 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.

3.2 Hemodynamic Goals - Updated 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.

3.2.1 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 mmHg[37,38] or greater than 100 mmHg[39] was associated with higher mortality and diminished functional recovery. One observational study found that mean arterial pressure (MAP) greater than 100 mmHg during 2 hours after ROSC was associated with better neurologic recovery at hospital discharge.[40] Another observational study found that survivors, compared with nonsurvivors, had higher MAP at 1 hour (96 versus 84 mmHg) and at 6 hours (96 versus 90 mmHg).[41]

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 mmHg improved mortality and neurologic outcome at hospital discharge.[42] One bundle with a goal of MAP over 75 mmHg found no change in functional recovery at hospital discharge.[43] One bundle with MAP greater than 65 mmHg increased survival to hospital discharge, with a favorable neurologic outcome at 1 year.[44] Another bundle with a goal MAP greater than 65 mmHg within 6 hours found no change in in-hospital mortality or functional recovery at hospital discharge.[45]

3.2.2 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 mmHg to greater than 80 mmHg. 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.

3.3 Vasopressors

Vasoactive drugs may be administered after ROSC to support cardiac output, especially blood flow to the heart and brain. Drugs may be selected to improve heart rate (chronotropic effects), myocardial contractility (inotropic effects), or arterial pressure (vasoconstrictive effects), or to reduce afterload (vasodilator effects). Unfortunately

many adrenergic drugs are not selective and may increase or decrease heart rate and afterload, increase cardiac arrhythmias, and increase myocardial ischemia by creating a mismatch between myocardial oxygen demand and delivery. Myocardial ischemia, in turn, may further decrease heart function. Some agents may also have metabolic effects that increase blood glucose, lactate, and metabolic rate. There is a paucity of data about which vasoactive drug to select first, although providers should become familiar with the differing adverse effects associated with these drugs, which might make a particular agent more or less appropriate for a specific patient.[46]

Specific drug infusion rates cannot be recommended because of variations in pharmacokinetics (relation between drug dose and concentration) and pharmacodynamics (relation between drug concentration and effect) in critically ill patients,[47,48] so commonly used initial dose ranges are listed in (Table 2). Vasoactive drugs must be titrated at the bedside to secure the intended effect while limiting side effects. Providers must also be aware of the concentrations delivered and compatibilities with previously and concurrently administered drugs.

Table 2: 2010 - Common Vasoactive Drugs

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Common Vasoactive Drugs	
Drug	**Typical Starting Dose (Then Titrate to Effect)**
Epinephrine	0.1–0.5 mcg/kg/min (In 70-kg adult, 7–35 mcg/min) • Useful for symptomatic bradycardia if atropine and transcutaneous pacing fail or if pacing is not available • Used to treat severe hypotension (eg, systolic blood pressure <70 mm Hg) • Useful for anaphylaxis associated with hemodynamic instability or respiratory distress[reference id="3971" range="" /]

Drug	Typical Starting Dose (Then Titrate to Effect)
Norepinephrine	0.1–0.5 mcg/kg/min (In 70-kg adult, 7–35 mcg/min) • Used to treat severe hypotension (eg, systolic blood pressure <70 mm Hg) and a low total peripheral resistance • Relatively contraindicated in patients with hypovolemia. It may increase myocardial oxygen requirements, mandating cautious use in patients with ischemic heart disease • Usually induces renal and mesenteric vasoconstriction; in sepsis, however, norepinephrine improves renal blood flow and urine output[reference id="3972" range="" /]·[reference id="3973" range="" /]
Phenylephrine	0.5–2.0 mcg/kg/min (In 70-kg adult, 35–140 mcg/min) • Used to treat severe hypotension (eg, systolic blood pressure <70 mm Hg) and a low total peripheral resistance
Dopamine	5–10 mcg/kg/min • Used to treat hypotension, especially if it is associated with symptomatic bradycardia • Although low-dose dopamine infusion has frequently been recommended to maintain renal blood flow or improve renal function, more recent data have failed to show a beneficial effect from such therapy[reference id="3974" range="" /]·[reference id="3975" range="" /]
Dobutamine	5–10 mcg/kg/min • The (+) isomer is a potent beta-adrenergic agonist, whereas the (–) isomer is a potent alpha-1-agonist[reference id="3976" range="" /] • The vasodilating beta2-adrenergic effects of the (+) isomer counterbalance the vasoconstricting alpha-adrenergic effects, often leading to little change or a reduction in systemic vascular resistance

Drug	Typical Starting Dose (Then Titrate to Effect)
Milrinone	Load 50 mcg/kg over 10 minutes then infuse at 0.375 mcg/kg/min • Used to treat low cardiac output • May cause less tachycardia than dobutamine

In general, adrenergic drugs should not be mixed with sodium bicarbonate or other alkaline solutions in the IV line because there is evidence that adrenergic agents are inactivated in alkaline solutions.[49,50] Norepinephrine (levarterenol) and other catecholamines that activate ?-adrenergic receptors may produce tissue necrosis if extravasation occurs. Therefore, administration through a central line is preferred whenever possible. If extravasation develops, infiltrate 5 to 10 mg of phentolamine diluted in 10 to 15 mL of saline into the site of extravasation as soon as possible to prevent tissue death and sloughing.

4 Targeted Temperature Management - Updated

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.[51] 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.

4.1 Induced Hypothermia - Updated ALS 790 ALS 791

4.1.1 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.[52, 53]

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 patientstreated with induced hypothermia.[54-56] 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).[57] One study reported reduced mortality at 6 months with induced hypothermia.[55]

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.[58]

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.[59] 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[52] or 28 hours[59] followed by a gradual (approximately 0.25ºC/hour) return to normothermia.

4.1.2 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; for non-VF/pVT (ie, "nonshockable") and in-hospital cardiac arrest). (Class I, LOE C-EO)

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 32º C and 36º C 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),[60,61] and lower temperatures might be preferred when patients have clinical features that are worsened at higher temperatures (eg, seizures, cerebral edema).[62-64] 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 36º C might be acceptable as well. Of note is that the recent randomized trial did not use active warming for the 36ºC group.[59] 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[2,3] 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.

4.2 Hypothermia in the Prehospital Setting - Updated 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.

4.2.1 2015 Evidence Summary

Five randomized controlled trials[65-69] 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,[70] and another trial compared intra-arrest intranasal cooling to no cooling.[71] 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[69].

4.2.2 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.

4.3 Avoidance of Hyperthermia - Updated 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.

4.3.1 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.[72-76]

After rewarming to normothermia from TTM, many studies have noted that fever occurs in a significant proportion of patients.[76-83] Occurrence of hyperthermia during the first few days after cardiac arrest was associated with worse outcome in 2 studies[82,83] but not in others.[76-81]

4.3.2 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.[84,85] 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.

5 Other Neurologic Care - Updated

Brain injury is a common cause of morbidity and mortality in post–cardiac arrest patients. Brain injury is the cause of death in 68% of patients after out-of-hospital cardiac arrest and in 23% after in-hospital cardiac arrest.[86] The pathophysiology of post–cardiac arrest brain injury involves a complex cascade of molecular events that are triggered by ischemia and reperfusion and then executed over hours to days after ROSC. Events and conditions in the post–cardiac arrest period have the potential to exacerbate or attenuate these injury pathways and impact ultimate outcomes. Clinical manifestations of post–cardiac arrest brain injury include coma, seizures, myoclonus, various degrees of neurocognitive dysfunction (ranging from memory deficits to persistent vegetative state), and brain death.[87]

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.

5.1 Seizure Management - Updated ALS 868 ALS 431

5.1.1 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%.[88-90] 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.[91-93]

Available evidence does not support prophylactic administration of anticonvulsant drugs. Two randomized clinical trials comparing anticonvulsants (thiopental[94] in one study and diazepam[88] 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[95] 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.[96] 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.

5.1.2 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)

5.2 Neuroprotective Drugs

The molecular events that cause neurodegeneration after cardiac arrest occur over hours to days after ROSC. This time course suggests a potentially broad therapeutic window for neuroprotective drug therapy. However, the number of clinical trials performed to date is limited and has failed to demonstrate improved neurological outcome with potential neuroprotective drugs given after cardiac arrest.

Few neuroprotective drugs have been tested in clinical trials, and only one published randomized trial[97] was performed in which a neuroprotective drug was combined with therapeutic hypothermia. No neuroprotection benefit was observed when patients (without hypothermia) were treated with thiopental, glucocorticoids, nimodipine, lidoflazine, diazepam, and magnesium sulfate. One trial using coenzyme Q10 in patients receiving hypothermia failed to show improved survival with good neurological outcome.[97]

The routine use of coenzyme Q10 in patients treated with hypothermia is uncertain. (Class IIb, LOE B)

6 Respiratory Care - Updated

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 $Paco_2$.

6.1 Ventilation - Updated ALS 571

6.1.1 2015 Evidence Summary

Systematic reviews examined whether ventilation to achieve and maintain a particular $Paco_2$ was associated with improved outcome. Two observational studies[98,99] found hypocapnia to be associated with a worse neurologic outcome, and 1 observational study found hypocapnia was associated with failure to be discharged home.[100] Observational studies did not find any consistent association between hypercapnia and outcome.[98-101]

6.1.2 2015 Recommendation - Updated

Maintaining the Paco2 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 mmHg or $Paco_2$ 35– 45 mmHg) 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.

6.2 Oxygenation - Updated 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.

6.2.1 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.[102-104] Other studies did not confirm this finding.[98,101,105-107] 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.[108] Most studies defined hypoxia as Pao_2 less than 60 mmHg, and hyperoxia as a Pao_2 greater than 300 mmHg. 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.[103,106,109] Preventing hypoxic episodes is considered more important than avoiding any potential risk of hyperoxia.

6.2.2 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 Fio2 and to monitor oxyhemoglobin saturation, it is reasonable to decrease the Fio2 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.

7 Treatment of Pulmonary Embolism After CPR

Fibrinolytic use may benefit patients with massive pulmonary emboli who have not had CPR,[110] and use of fibrinolytics to treat pulmonary embolism after CPR has been reported.[111] The use of fibrinolytics during CPR has been studied, and CPR itself does not appear to pose an unacceptable risk of bleeding.[112-120] Alternatively, surgical embolectomy has also been used successfully in some patients after PE-induced cardiac arrest.[116,121-124] Mechanical thrombectomy was employed in a small case series and only one of seven patients died and pulmonary perfusion was restored in the majority (85.7%).[114]

In post–cardiac arrest patients with arrest due to presumed or known pulmonary embolism, fibrinolytics may be considered. (Class IIb, LOE C)

8 Sedation After Cardiac Arrest

Patients with coma or respiratory dysfunction after ROSC are routinely intubated and maintained on mechanical ventilation for a period of time, which results in discomfort, pain, and anxiety. Intermittent or continuous sedation and/or analgesia can be used to achieve specific goals. Patients with post–cardiac arrest cognitive dysfunction may display agitation or frank delirium with purposeless movement and are at risk of self-injury. Opioids, anxiolytics, and sedative-hypnotic agents can be used in various combinations to improve patient-ventilator interaction and blunt the stress-related surge of endogenous catecholamines. Other agents with sedative and antipsychotic-tranquilizer properties, such as $?_2$-adrenergic agonists,[125] and butyrophenones[126] are also used based on individual clinical circumstances.

If patient agitation is life-threatening, neuromuscular blocking agents can be used for short intervals with adequate sedation. Caution should be used in patients at high risk of seizures unless continuous electroencephalographic (EEG) monitoring is available. In general sedative agents should be administered cautiously with daily interruptions and titrated to the desired effect. A number of sedation scales[127-132] and motor activity scales[133] were developed to titrate these pharmacological interventions to a clinical goal.

Shorter-acting medications that can be used as a single bolus or continuous infusion are usually preferred. There is little evidence to guide sedation/analgesia therapy immediately after ROSC. One observational study[134] found an association between use of sedation and development of pneumonia in intubated patients during the first 48 hours of therapy. However, the study was not designed to investigate sedation as a risk factor for either pneumonia or death in patients with cardiac arrest.

Although minimizing sedation allows a better clinical estimate of neurological status, sedation, analgesia, and occasionally neuromuscular relaxation are routinely used to facilitate induced hypothermia and to control shivering. The duration of neuromuscular blocker use should be minimized and the depth of neuromuscular blockade should be monitored with a nerve twitch stimulator.

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)

Duration of neuromuscular blocking agents should be kept to a minimum or avoided altogether.

9 Other Critical Care Interventions - Updated

Cardiac arrest is thought to involve multiorgan ischemic injury and microcirculatory dysfunction.[135,136,137] Implementing a protocol for goal-directed therapy using fluid and vasoactive drug administration along with monitoring of central venous oxygen saturation may improve survival from sepsis,[138] suggesting that a similar approach may benefit post–cardiac arrest patients. By analogy, studies have explored several other interventions believed to be beneficial in sepsis or other critical illness.

9.1 Glucose Control - Updated 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.

9.1.1 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.[139] 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.[44] No data suggest that the approach to glucose management chosen for other critically ill patients should be modified for cardiac arrest patients.[140-142]

9.1.2 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)

9.2 Steroids

Corticosteroids have an essential role in the physiological response to severe stress, including maintenance of vascular tone and capillary permeability. In the post–cardiac arrest phase, several authors report a relative adrenal insufficiency compared with the metabolic demands of the body.[143,144] Relative adrenal insufficiency in the post–cardiac arrest phase was associated with higher rates of mortality.[143-145]

At present there are no human randomized trials investigating corticosteroid use after ROSC. One investigation combined steroid therapy with use of vasopressin, which made interpretation of results specific to steroids impossible.[146] The post–cardiac arrest syndrome has similarities to septic shock, but the efficacy of corticosteroids remains controversial in patients with sepsis as well.[135,147-149] Whether the provision of corticosteroids in the post–cardiac arrest phase improves outcome remains unknown and the value of the routine use of corticosteroids for patients with ROSC following cardiac arrest is uncertain.

9.3 Hemofiltration

Hemofiltration has been proposed as a method to modify the humoral response to the ischemic-reperfusion injury that occurs after cardiac arrest. In a single randomized controlled trial there was no significant difference in 6-month survival among the groups.[150] Future investigations are required to determine whether hemofiltration will improve outcome in post–cardiac arrest patients.

10 Prognostication of Outcome - Updated

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.[151]

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 recoverquickly 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.

10.1 Timing of Outcome Prediction - Updated 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.

10.1.1 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.[152,153] 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[154] and to wait for some period of time after return of normothermia for those using TTM.[155]

10.1.2 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.

10.2 Clinical Examination Findings That Predict Outcome - Updated 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.

10.2.1 2015 Evidence Summary

The 2015 ILCOR systematic review examined pupillary light reflexes, corneal reflexes, and motor response for predictionof 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%).[156-160] Bilaterally absent corneal reflexes at 72 to 120 hours after cardiac arrest predicted poor outcome, with a 2% FPR (95% CI, 0%–7%).[158-161] 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%).[156,158,160,162-164] 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%).[165,166] 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.[166-168] 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%).[166,169] 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%).[92,156,162,163,170,171] In 1 study,[164] 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,[89,159,160] 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 earlyonset and prolonged myoclonus evolved into a chronic action myoclonus (Lance-Adams syndrome).[170,172-174] 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%)[175] at 24 hours after cardiac arrest[168] (FPR, 0%; 95% CI, 0%–7%) or within 72 hours of cardiac arrest[166,176] (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.

10.2.2 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)

10.3 EEG Findings to Predict Outcome - Updated 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.[177]

10.3.1 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%),[178,179] but 2 other studies reported that EEG during TTM predicted poor outcome, with a 6% FPR (95% CI, 1%– 15%).[163,180] Burst suppression after rewarming was associated with poor outcome[179] (FPR, 0%; 95% CI, 0%–5%). Some studies reported good outcome despite the presence of epileptiform discharges during TTM.[162,181] In several case series, no patients with electrographic seizures during or after TTM had good outcome,[92,162,181-183] but other studies reported cases with good outcome when seizures occurred in the presence of a reactive EEG background.[170,179] Absence of EEG reactivity during TTM predicted poor outcome, with an FPR of 2% (95% CI, 1%–7%),[92,163,171] and absence of EEG reactivity after rewarming predicted poor outcome, with an FPR of 0% (95% CI, 0%–3%).[92,162,163] Low-voltage EEG,[179] low bispectral index,[184] and EEG grades[92] 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%),[185-187] and burst suppression at 72 hours after cardiac arrest predicted poor outcome, with a 0% FPR (95% CI, 0%–11%).[166] EEG grades were not defined consistently between studies. Low-voltage EEG (?20 to 21 ?V) predicted poor outcome, with 0%FPR (95% CI, 0%–5%) within 48 hours after cardiac arrest (1 study)[168] and with 0% FPR (95% CI, 0%–11%) at 72 hours after cardiac arrest.[166] However, low-voltage EEG is not reliable, because a variety of technical factors can affect EEG amplitude.

10.3.2 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)

10.4 Evoked Potentials to Predict Outcome - Updated 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.

10.4.1 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%).[156,180,188,189] Absent N20 after rewarming predicted poor outcome, with a 1% FPR (95% CI, 0%–3%).[156-158,160,162-164,171,190,191] 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[155] 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%).[167,189,192-200] Only 1 case of a false-positive result from absent SSEP in a patient not treated with TTM was identified.[168] Again, these studies may have allowed treating teams to act on the results of the SSEP, potentially inflating the accuracy of this test.

10.4.2 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.[189,201]

10.5 Imaging Tests to Predict Outcome - Updated 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 graywhite 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.[157] Brain edema on MRI is a sensitive marker of focal injury and is detected by restricted diffusion on diffusion-weighted imaging (DWI) sequences[202] and can be quantified by using apparent diffusion coefficient (ADC). Normal ADC values range between 700 and 800 × 10?6 mm2 /s and decrease with edema.[203]

10.5.1 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%.[157,204-206] 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[159] (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%).[207] 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.[208,209]

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[210] (FPR, 0%; 95% CI, 0%–78%). Low ADC at the level of putamen, thalamus, or occipital cortex predicted poor outcome, with 0% FPR[211] (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%).[202] Extensive (cortex, basal ganglia, and cerebellum) DWI changes predicted poor outcome, with a 0% FPR (95% CI, 0%–45%).[212] Whole-brain ADC less than 665 × $10^{?6}$ mm^2/s predicted poor outcome, with 0% FPR (95% CI, 0%–21%).[213] 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%).[210] 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%).[169,203]

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,[210] with most studies examining patients 3 to 7 days after cardiac arrest.

10.5.2 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.[214] 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.

10.6 Blood Markers to Predict Outcome - Updated 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.

10.6.1 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.[156,158-160,163,166,171,183,184,196,198,206,211,215-227] 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.

10.6.2 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.

11 Organ Donation - Updated 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.

11.1 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.[228] When patients who have previously had cardiopulmonary resuscitation proceed to become organ donors, each donor provides a mean of 3.9[229] or 2.9[228] 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,[228,230-236] pediatric hearts,[228,237-240] adult lungs,[228,234,241] pediatric lungs,[228] adult kidneys,[228,242] pediatric kidneys,[228,239] adult livers,[228,230] pediatric livers,[228,239] adult intestines,[228,243] and pediatric intestines.[228] 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[244] or 3.2[245] organs were procured from each donor in these programs. Function of adult kidneys[246-248] or adult livers[244,247,249] from these donors was similar immediately, 1 year, and 5 years after transplantation.

11.2 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.

12 Conclusions and Future Directions - Updated

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.

13 Authorship and Disclosures

13.1 2015 Writing Team

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Table 3: Part 8: Post–Cardiac Arrest Care: 2015 Guidelines Update Writing Group Disclosures

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

Writing Group Member	Employment	Research Grant	Other Research Support	Speakers' Bureau/Honora	Expert Witness	Ownership Interest	Consultant/Advis Board	Other
Clifton W. Callaway	University of Pittsburgh; UPMC Health System	None	None	None	None	None	None	None
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Romergryko G. Geocadin	Johns Hopkins University School of Medicine	NIH†	None	None	Medicolegal consulting*	None	None	None
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Michael W. Donnino	Beth Israel Deaconess Med Center	American Heart Association†	None	None	None	None	American Heart Association†	None

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.

13.2 2010 Writing Team

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Table 4: 2010 - Guidelines Part 9: Post–Cardiac Arrest Care: Writing Group Disclosures

Open table in a new window

2010 Guidelines Part 9: Post–Cardiac Arrest Care: Writing Group Disclosures

Writing Group Member	Employment	Research Grant	Other Research Support	Speakers' Bureau/Honorari	Ownership Interest	Consultant/Advisc Board	Other
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Clifton W. Callaway	University of Pittsburgh School of Medicine–Assc Professor; UPMC Health System–Physi	†Grants to University of Pittsburgh: NHLBI-Resuscitation Outcomes Consortium HRSA-Development and Dissemination of Program Tools for Uncontrolled Donation After Cardiac Death (UDCD)	*Loan of an Arctic Sun cooling device (without disposables) to human physiology laboratory for experiments on hypothermia by Medivance, Inc.	None	†Co-inventor on patent about ventricular fibrillation waveform analysis, licensed by University of Pittsburgh to Medtronic ERS, Inc.	None	None

Writing Group Member	Employment	Research Grant	Other Research Support	Speakers' Bureau/Honorari	Ownership Interest	Consultant/Advisc Board	Other
Robert W. Neumar	University of Pennsylvania–Associate Professor of Emergency Medicine	†Funding Source: NIH/NINDS Grant Number: R21 NS054654 Funding Period 06/01/07 to 06/31/2010 Role on Project: Principal Investigator Title: Optimizing Therapeutic Hypothermia After Cardiac Arrest Description: The goal of this project is to evaluate how the onset and duration of therapeutic hypothermia after cardiac arrest impacts survival and neuroprotection	None	None	None	None	None
Romergryko G. Geocadin	Johns Hopkins University School of Medicine–Asso Professor of Neurology, Anesthesiology Critical Care Medicine and Neurosurgery	†NIH RO1 Grant: “Consequence of Cardiac Arrest: Brain Injury” *NIH R44 Grant: “Cortical Injury Monitor Phase IIB”	None	*Academic Grand Rounds American Academy of Neurology	None	None	*Guest Editor: Neurology Clinics, Emergency Medicine Clinics, and Seminars in Neurology

Writing Group Member	Employment	Research Grant	Other Research Support	Speakers' Bureau/Honorari	Ownership Interest	Consultant/Advisc Board	Other
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Michael Donnino	Harvard Medical Faculty Physicians–Ph	† Corticosteroids in Post-cardiac Arrest Patients [Scientist Development Grant, American Heart Association] Thiamine as a Metabolic Resuscitator in Septic Shock [Pending] * Thiamine Deficiency in Septic Shock [completed, NIH through Harvard Medical School] Statin Therapy in Sepsis [Eleanor Shores Grant-nonindustry]	None	None	None	None	None
Andrea Gabrielli	University of Florida–Professor of Anesthesiology and Surgery	†NIH-Biomarkers and Traumatic Brain Injury	None	None	None	None	None

Writing Group Member	Employment	Research Grant	Other Research Support	Speakers' Bureau/Honorari	Ownership Interest	Consultant/Advisc Board	Other
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Arno L. Zaritsky	Children's Hospital of the King's Daughters–Sr. VP for Clinical Services	None	None	None	None	*Data Safety Monitoring Board for NIH-sponsored clinical trial of therapeutic hypothermia after pediatric cardiac arrest	None
Raina Merchant	University of Pennsylvania–fellow	None	None	None	None	None	None
Terry L. Vanden Hoek	University of Chicago–Associate Professor	*Principal Investigator 09/06/04–04/30/10 DOD/Office of Naval Research $885 639 Proteomic Development of Molecular Vital Signs: Mapping a Mitochondrial Injury Severity Score to Triage and Guide Resuscitation of Hemorrhagic Shock. This research grant is awarded to the University of Chicago	None	None	*Hypothermia Induction Patents (3 approved, 3 pending) no income	None	None

Writing Group Member	Employment	Research Grant	Other Research Support	Speakers' Bureau/Honorari	Ownership Interest	Consultant/Advisc Board	Other
Steven L. Kronick	University of Michigan Health System Healthcare institution Assistant Professor	None	None	None	None	None	*Expert Witness: Reviewed a single case for an attorney. Less than 4 hours work total

- 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.

14 Footnotes

The American Heart Association requests that this document be cited as follows:

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