# Part 10: Special Circumstances of Resuscitation

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

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### Introduction

This Part of the *2015 American Heart Association* (AHA) *Guidelines Update for Cardiopulmonary Resuscitation* (CPR) *and Emergency Cardiovascular Care* (ECC) addresses cardiac arrest in situations that require special treatments or procedures other than those provided during basic life support (BLS) and advanced cardiovascular life support (ACLS).

This Part summarizes recommendations for the management of resuscitation in several critical situations, including cardiac arrest associated with pregnancy (Part 10.1), pulmonary embolism (PE) (10.2), and opioid-associated resuscitative emergencies, with or without cardiac arrest (10.3). Part 10.4 provides recommendations on intravenous lipid emulsion (ILE) therapy, an emerging therapy for cardiac arrest due to drug intoxication. Finally, updated guidance for the management of cardiac arrest during percutaneous coronary intervention (PCI) is presented in Part 10.5. A table of all recommendations made in this 2015 Guidelines Update as well as those made in the 2010 Guidelines is contained in the Appendix.

The special situations of resuscitation section (Part 12) of the *2010 AHA Guidelines for CPR and ECC*[1] covered 15 distinct topic areas. The following topics were last updated in 2010:

- Management of cardiac arrest associated with asthma (Part 12.1)
- Anaphylaxis (12.2)
- Morbid obesity (12.4)
- Electrolyte imbalance (12.6)
- Trauma (12.8)
- Accidental hypothermia (12.9)
- Avalanche (12.10)
- ACLS treatment of cardiac arrest due to drowning (12.11)
- Electric shock or lightning strikes (12.12)
- Cardiac tamponade (12.14)
- Cardiac surgery (12.15)
- Toxic effects of benzodiazepines, β-blockers, calcium channel blockers, digoxin, cocaine, cyclic antidepressants, carbon monoxide, and cyanide (12.7)

Additional information about drowning is presented in Part 5 of this publication, "Adult Basic Life Support and Cardiopulmonary Resuscitation Quality."

The recommendations in this 2015 Guidelines Update are based on an extensive evidence review process that was begun by the International Liaison Committee on Resuscitation (ILCOR) with the publication of the ILCOR *2010 International Consensus on CPR and ECC Science With Treatment Recommendations* (CoSTR)[2] and was completed with the preparation of the 2015 CoSTR publication.[3,4]

In the in-depth international evidence review process, the ILCOR task forces examined topics and then generated prioritized lists of questions for systematic review. The process by which topics were prioritized for review are described in the CoSTR publication.[5,6] Questions were first formulated in PICO (population, intervention, comparator, outcome) format,[7] the search strategy and inclusion and exclusion criteria were defined, and then a search for relevant articles was performed. The evidence was evaluated by using the standardized methodological approach proposed by the Grading of Recommendations Assessment, Development and Evaluation (GRADE) Working Group.[8]

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. Further information about this international evidence evaluation process can be found in the 2015 CoSTR, "Part 2: Evidence Evaluation and Management of Conflicts of Interest."[9,10]

To create this 2015 Guidelines Update, the AHA formed 15 writing groups, with careful attention to avoid or manage conflicts of interest, to assess the ILCOR treatment recommendations and to write AHA treatment recommendations by using the AHA Class of Recommendation and Level of Evidence (LOE) system. The recommendations made in this 2015 Guidelines Update are informed by the ILCOR recommendations and GRADE classification of the systematic reviews in the context of the delivery of medical care in North America. In the online version of this publication, live links

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are provided so the reader can connect directly to those systematic reviews on the ILCOR Scientific Evidence Evaluation and Review System (SEERS) website. These links are indicated by a combination of letters and numbers (eg, ALS 436). We encourage readers to use the links and review the evidence and appendixes, such as the GRADE tables. Further information about this evidence evaluation process can be found in "Part 2: Evidence Evaluation and Management of Conflicts of Interest" of this 2015 Guidelines Update.

Contemporaneous with the ILCOR evidence-review process, the AHA ECC Committee; Council on Cardiopulmonary, Critical Care, Perioperative, and Resuscitation; Council on Cardiovascular Diseases in the Young; and Council on Clinical Cardiology have developed an AHA Scientific Statement on cardiac arrest in pregnancy.[11] While Part 10.1 of this 2015 Guidelines Update provides treatment recommendations for the intra-arrest management of pregnant patients, a full discussion of preparation, prevention, resuscitation, emergency delivery, and postresuscitation care are beyond the scope of this article. Readers are directed to the full Scientific Statement for more complete recommendations.

## Part 10.1: Cardiac Arrest Associated With Pregnancy[ALS 436]

Cardiac arrest associated with pregnancy is rare in high-income countries. Maternal cardiac arrest occurs in approximately 1:12 000 admissions for delivery in the United States.[12] Maternal cardiac arrest rates appear to be increasing in the United States, from 7.2 deaths per 100 000 live births in 1987 to 17.8 deaths per 100 000 live births in 2009.[13] Maternal mortality rates are lower in Canada, where maternal mortality is reported as 6.1 deaths per 100 000 deliveries, with a decreasing trend from 2001 until 2011.[14,15]

The best outcomes for both mother and fetus are likely to be achieved by successful maternal resuscitation. The most common causes of maternal cardiac arrest are hemorrhage, cardiovascular diseases (including myocardial infarction, aortic dissection, and myocarditis), amniotic fluid embolism, sepsis, aspiration pneumonitis, PE, and eclampsia.[12,16] Important iatrogenic causes of maternal cardiac arrest include hypermagnesemia from magnesium sulfate administration and anesthetic complications.

The 2015 ILCOR systematic review addressed the questions of patient positioning during CPR and the role of perimortem cesarean delivery (PMCD) in the management of pregnant women in cardiac arrest during the second half of pregnancy.

### 2015 Evidence Summary

The evidence regarding advanced treatment strategies for cardiac arrest in pregnancy is largely observational. As a result, the recommendations are based on application of physiologic principles and on close examination of observational studies that are susceptible to bias. The lack of high-quality studies examining treatment of cardiac arrest in late pregnancy represents a major scientific gap.

#### *Patient Positioning During CPR*

Patient position has emerged as an important strategy to improve the quality of CPR and resultant compression force and cardiac output. The gravid uterus can compress the inferior vena cava, impeding venous return, thereby reducing stroke volume and cardiac output. In general, aortocaval compression can occur for singleton pregnancies at approximately 20 weeks of gestational age,[17] at about the time when the fundus is at or above the umbilicus. Although chest compressions in the left lateral tilt position are feasible in a manikin study,[18] they result in decreased CPR quality (less forceful chest compressions) than is possible in the supine position.[19] Manual left lateral uterine displacement (LUD) effectively relieves aortocaval pressure in patients with hypotension[20] (Figure 1). No cardiac arrest outcome studies have been published examining the effect of LUD or other strategies to relieve aortocaval compression during resuscitation.

#### *Emergency Cesarean Delivery in Cardiac Arrest*

Evacuation of the gravid uterus relieves aortocaval compression and may improve resuscitative efforts.[21–25] In the latter half of pregnancy, PMCD may be considered part of maternal resuscitation, regardless of fetal viability.[26] In a case series, 12 of 20 women for whom maternal outcome was recorded who underwent PMCD during resuscitation had return of spontaneous circulation (ROSC) immediately after delivery,

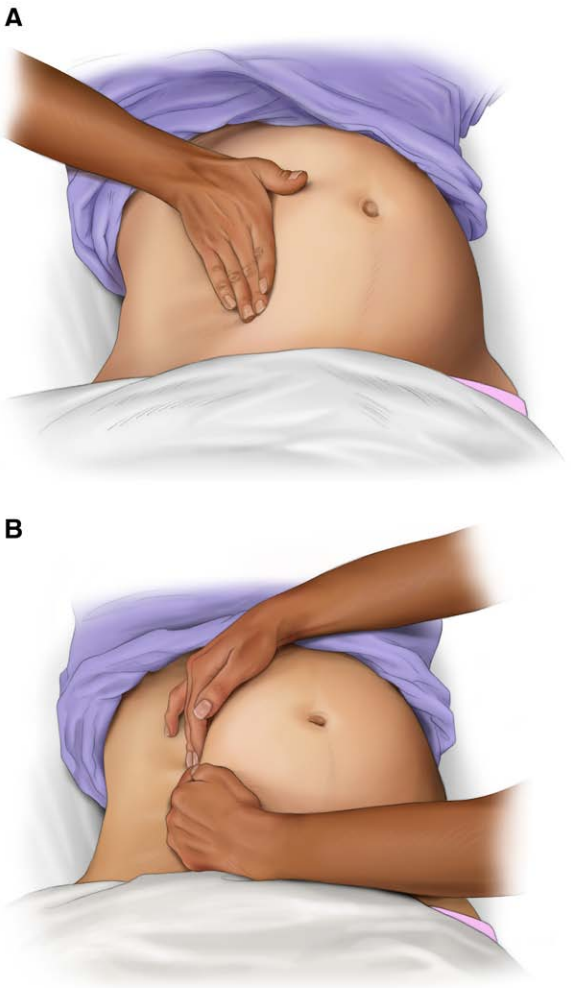


**Figure 1. A**, Manual LUD, performed with one-handed technique. **B**, Two-handed technique during resuscitation.

and no cases of worsening maternal status were reported.[27] A systematic review of the literature evaluated all case reports of cardiac arrest in pregnancy, but the wide range of case heterogeneity and reporting bias does not allow for any conclusions regarding the timing of PMCD.[28] Survival of the mother has been reported up to 15 minutes after the onset of maternal cardiac arrest.[21,29–31] Neonatal survival has been documented with PMCD performed up to 30 minutes after the onset of maternal cardiac arrest.[21]

### 2015 Recommendations—New and Updated

#### *BLS Modification: Relief of Aortocaval Compression*

Priorities for the pregnant woman in cardiac arrest are provision of high-quality CPR and relief of aortocaval compression (Class I, LOE C-LD). If the fundus height is at or above the level of the umbilicus, manual LUD can be beneficial in relieving aortocaval compression during chest compressions (Class IIa, LOE C-LD).

#### *ALS Modification: Emergency Cesarean Delivery in Cardiac Arrest*

Because immediate ROSC cannot always be achieved, local resources for a PMCD should be summoned as soon as cardiac arrest is recognized in a woman in the second half of pregnancy (Class I, LOE C-LD). Systematic preparation and training are the keys to a successful response to such rare and complex events. Care teams that may be called upon to manage these situations should develop and practice standard institutional responses to allow for smooth delivery of resuscitative care (Class I, LOE C-EO).

During cardiac arrest, if the pregnant woman with a fundus height at or above the umbilicus has not achieved ROSC with usual resuscitation measures plus manual LUD, it is advisable to prepare to evacuate the uterus while resuscitation continues (Class I, LOE C-LD). In situations such as nonsurvivable maternal trauma or prolonged pulselessness, in which maternal resuscitative efforts are obviously futile, there is no reason to delay performing PMCD (Class I, LOE C-LD). PMCD should be considered at 4 minutes after onset of maternal cardiac arrest or resuscitative efforts (for the unwitnessed arrest) if there is no ROSC (Class IIa, LOE C-EO). The clinical decision to perform a PMCD—and its timing with respect to maternal cardiac arrest—is complex because of the variability in level of practitioner and team training, patient factors (eg, etiology of arrest, gestational age), and system resources.

## Part 10.2: Cardiac Arrest Associated With Pulmonary Embolism[ALS 435]

PE is a potentially reversible cause of shock and cardiac arrest. Acute increase in right ventricular pressure due to pulmonary artery obstruction and liberation of vasoactive mediators produces cardiogenic shock that may rapidly progress to cardiovascular collapse. Management of acute PE is determined by disease severity.[32] Fulminant PE, characterized by cardiac arrest or severe hemodynamic instability, defines the subset of massive PE that is the focus of these recommendations.[33]

Less than 5% of patients with acute PE progress to cardiac arrest. Disease of this severity is associated with mortality of 65% to 90%.[34–36] PE-related cardiac arrests may occur within hours of symptom onset. Between 5% and 13% of unexplained cardiac arrests are associated with fulminant PE.[37,38]

Because establishing the diagnosis of acute PE in cardiac arrest situations is often difficult, separate systematic reviews were performed for management of patients with suspected and confirmed PE. Although clinical markers specific to fulminant PE are limited, acute symptoms frequently prompt medical attention before cardiac arrest. Conventional thromboembolism risk factors, prodromal dyspnea or respiratory distress, and witnessed arrest are features associated with cardiac arrest due to PE.[37,39] Pulseless electrical activity is the presenting rhythm in 36% to 53% of PE-related cardiac arrests, while primary shockable rhythms are uncommon.[37,40,41] Specific recommendations about the use of diagnostic ultrasonography during resuscitation can be found in "Part 7: Adult Advanced Cardiovascular Life Support" in this 2015 Guidelines Update.

Prompt systemic anticoagulation is generally indicated for patients with massive and submassive PE to prevent clot propagation and support endogenous clot dissolution over weeks.[42] Anticoagulation alone is inadequate for patients with fulminant PE. Pharmacologic and mechanical therapies to rapidly reverse pulmonary artery occlusion and restore adequate pulmonary and systemic circulation have emerged as primary therapies for massive PE, including fulminant PE.[32,43] Current advanced treatment options include systemic thrombolysis, surgical or percutaneous mechanical embolectomy, and extracorporeal cardiopulmonary resuscitation (ECPR).

The 2015 ILCOR systematic review addressed the treatment of PE as the known or suspected cause of cardiac arrest. The role of thrombolytic medications in the management of undifferentiated cardiac arrest was last reviewed in the 2010 Guidelines and is not reviewed again here.[44]

### 2015 Evidence Summary

The evidence regarding advanced treatment strategies for fulminant PE is largely observational. The lack of high-quality studies examining treatment of cardiac arrest due to PE represents a major scientific gap.

#### *Confirmed Pulmonary Embolism*

Systemic thrombolysis is associated with ROSC and short-term survival in PE-related cardiac arrest in nonrandomized observational studies.[37,45–54]

There is no consensus on the ideal dose of thrombolytic therapy in PE-associated cardiac arrest. Contemporary examples of accelerated emergency thrombolysis dosing regimens for fulminant PE include alteplase 50 mg intravenous (IV) bolus with an option for repeat bolus in 15 minutes, or single-dose weight-based tenecteplase; thrombolytics are administered with or followed by systemic anticoagulation.[55–57] Early administration of systemic thrombolysis is associated with improved resuscitation outcomes compared with use after failure of conventional ACLS.[46]

Successful surgical and percutaneous mechanical embolectomy in cases of PE-related cardiac arrest have been reported in limited series.[58–60] Many of these patients developed cardiac arrest before or during embolectomy. The feasibility of embolectomy under uncontrolled CPR conditions is not known.

### *Suspected Pulmonary Embolism*

No evidence is available to support or refute the effectiveness of empiric thrombolysis in suspected but unconfirmed PE.

## 2015 Recommendations—New and Updated

### *ALS Modification: Confirmed Pulmonary Embolism*

In patients with confirmed PE as the precipitant of cardiac arrest, thrombolysis, surgical embolectomy, and mechanical embolectomy are reasonable emergency treatment options (Class IIa, LOE C-LD). Comparative data are not available to recommend one strategy over another. Patient location, local intervention options, and patient factors (including thrombolysis contraindications) are recognized elements to be considered. Thrombolysis can be beneficial even when chest compressions have been provided (Class IIa, LOE C-LD). Given the poor outcomes associated with fulminant PE in the absence of clot-directed therapy, standard contraindications to thrombolysis may be superseded by the need for potentially lifesaving intervention.

### *ALS Modifications: Suspected Pulmonary Embolism*

Thrombolysis may be considered when cardiac arrest is suspected to be caused by PE (Class IIb, LOE C-LD). There is no consensus on inclusion criteria (eg, risk factors, signs, or symptoms that constitute suspected PE), thrombolytic timing, drug, or dose in this situation. There are insufficient data on surgical and mechanical embolectomy to evaluate these therapies for cardiac arrest associated with suspected but unconfirmed PE.

# Part 10.3: Cardiac or Respiratory Arrest Associated With Opioid Overdose[ALS 441,BLS 811,BLS 891]

In the United States in 2013, 16 235 people died of prescription opioid toxicity, and an additional 8257 died of heroin overdose.[61,62] In the United States in 2012, opioid overdose became the leading cause of unintentional injurious death in people aged 25 to 60 years, accounting for more deaths than motor vehicle collisions.[63] A majority of these deaths are associated with prescription opioids. Statistics are similar in Canada.[64]

Isolated opioid toxicity is associated with central nervous system (CNS) and respiratory depression that can progress to respiratory and cardiac arrest. Most opioid deaths involve the co-ingestion of multiple drugs or medical and mental health comorbidities.[65–68] In addition, methadone and propoxyphene can cause *torsades de pointes*, and cardiotoxicity has been reported with other opioids.[69–75] Except in specific clinical settings (eg, unintended opioid overdose during a medical procedure), rescuers cannot be certain that the patient's clinical condition is due to opioid-induced CNS and respiratory depression toxicity alone, and might therefore misidentify opioid-associated cardiac arrest as unconsciousness or *vice versa*. This is particularly true in the first aid and BLS contexts, where determination of the presence or absence of a pulse is unreliable.[76,77] Any treatment recommendations intended for use in the first aid or BLS settings must therefore have benefit that exceeds harm when applied to a mixed patient population that may include people with severe CNS and respiratory depression, respiratory arrest, and cardiac arrest.

In creating this 2015 Guidelines Update, the writing group considered the difficulty in accurately differentiating opioid-associated resuscitative emergencies from other causes of cardiac and respiratory arrest. Opioid-associated resuscitative emergencies are defined by the presence of cardiac arrest; respiratory arrest; or severe life-threatening instability (such as severe CNS or respiratory depression, hypotension, or cardiac arrhythmia) that is suspected to be due to opioid toxicity. The term "opioid-associated life-threatening emergency" is used for first aid and non-healthcare providers.

Naloxone is a potent opioid receptor antagonist in the brain, spinal cord, and gastrointestinal system. Naloxone has an excellent safety profile and can rapidly reverse CNS and respiratory depression in a patient with an opioid-associated resuscitative emergency. Based on the rescuer's training and clinical circumstance, naloxone can be administered intravenously,[78–81] intramuscularly,[78,79,82] intranasally,[80,82–86] or subcutaneously[87]; nebulized for inhalation[88,89]; or instilled into the bronchial tree via endotracheal tube.[90] Appropriate dose and concentrations differ by route.

There are no known harms or major clinical effects associated with the administration of naloxone in typical doses to patients who are not opioid-intoxicated or dependent.[91,92] Naloxone administration may precipitate acute withdrawal syndrome in patients with opioid dependency, with signs and symptoms including hypertension, tachycardia, piloerection, vomiting, agitation, and drug cravings. These signs and symptoms are rarely life-threatening, and they may be minimized by using the lowest effective dose of naloxone.[93] Pulmonary edema has been reported with naloxone administration, but it also may be caused primarily by opioid toxicity.[93]

The ideal dose of naloxone is not known. In the 2010 Guidelines, an empiric starting dose of 0.04 to 0.4 mg IV or intramuscular (IM) was recommended to avoid provoking severe opioid withdrawal in patients with opioid dependency and to allow for consideration of a range of doses, depending on the clinical scenario.[1] Repeat doses or dose escalation to 2 mg IV or IM was recommended if the initial response was inadequate. Few comparative data exist about the appropriate dose of intranasal (IN) naloxone; most studies used a fixed dose of 2 mg, repeated in 3 to 5 minutes if necessary.[80,82–86,94] Nebulized naloxone has been studied and well-tolerated in opioid-intoxicated patients at a dose of 2 mg diluted in 3 mL normal saline.[88,89] Regardless of the care setting and route of administration, the initial goal of therapy is to restore and maintain patent airway and ventilation, preventing respiratory and cardiac arrest, without provoking severe opioid withdrawal.

The 2015 ILCOR systematic review addressed the questions of whether opioid overdose response education (with or without naloxone distribution) improves outcomes related to opioid overdose and whether naloxone administration or any other therapy improves outcomes in the patients with opioid-associated cardio/respiratory arrest in the first aid, BLS, or ACLS settings.

## 2015 Evidence Summary

### *Opioid Overdose Response Education and Naloxone Training and Distribution*

Several studies have shown that community-based opioid overdose response education and naloxone distribution programs are feasible and that naloxone administration occurs frequently by persons trained by these programs.[95] Because patients who have CNS and respiratory depression from opioid overdose cannot self-administer naloxone, naloxone is typically administered in the first aid setting by friends, family, or bystanders.[96,97]

In 2014, the US Food and Drug Administration approved of the use of a naloxone autoinjector by lay rescuers[98] as well as healthcare providers. Both the IM and IN[95] routes of administration have been successfully used in first aid settings, with commercially available devices or kits containing a naloxone vial or prefilled syringe and a nasal atomizer or other administration device. IM, IN, and nebulized routes of administration have also been used to treat opioid-associated resuscitative emergencies in the BLS and ACLS settings.[79,80,88,99] Recent recommendations by an international working group called for uniform training standards based on simplified (first aid) resuscitation principles for community-based naloxone distribution programs.[100]

### *Administration of Naloxone in Opioid-Associated Resuscitation Emergencies*

*Respiratory Arrest*

Two clinical trials and 12 observational studies examined outcomes after naloxone treatment for opioid-induced respiratory arrest or severe CNS and respiratory depression. Of these, 5 studies compared routes of naloxone administration,[80,82,83,87,101] and 9 assessed the safety of naloxone use or were observational studies of naloxone use alone.[79,102–109] All studies reported improvement in level of consciousness and spontaneous breathing after naloxone administration in the majority of patients treated, and complication rates were low. No study compared resuscitation outcomes achieved with naloxone with those achieved through standard therapy alone (eg, manual or mechanical ventilation).

*Cardiac Arrest*

One small observational study noted an improvement in cardiac rhythm in some patients after naloxone administration, but it did not compare outcomes in patients managed with and without naloxone administration.[110]

## 2015 Recommendations—New

### *Opioid Overdose Response Education and Naloxone Training and Distribution*

It is reasonable to provide opioid overdose response education, either alone or coupled with naloxone distribution and training, to persons at risk for opioid overdose (Class IIa, LOE C-LD). Some populations that may benefit from opioid overdose response interventions are listed in Table 1. It is reasonable to base this training on first aid and non–healthcare provider BLS recommendations rather than on more advanced practices intended for healthcare providers (Class IIa, LOE C-EO).

**Table 1. Groups That May Benefit From Opioid Overdose Response Education and/or Naloxone Distribution and Training[100,111–119]**

- Persons who abuse prescription opioids or heroin
- Patients who have required emergency care for opioid overdose
- Patients enrolled in opioid dependence treatment programs, including methadone and buprenorphine maintenance programs, particularly at high-risk periods, such as induction or discharge
- Persons with a history of opioid abuse or dependence who are being released from prison
- Patients receiving prescription opioid therapy with risk factors for adverse effects
  - Coprescriptions of benzodiazepines or other sedatives
  - Ongoing alcohol use
  - High-dose prescription opioid therapy
- Persons living with or in frequent contact with those listed above

### *First Aid and Non–Healthcare Provider BLS Modification: Administration of Naloxone*

Although naloxone has no clear role in the management of confirmed cardiac arrest, first aid and other non-healthcare providers are not instructed to attempt to determine whether an unresponsive person is pulseless. Empiric administration of IM or IN naloxone to all unresponsive opioid-associated life-threatening emergency patients may be reasonable as an adjunct to standard first aid and non–healthcare provider BLS protocols (Class IIb, LOE C-EO). Standard resuscitation, including activation of emergency medical services, should not be delayed for naloxone administration. However, family members and friends of those known to be addicted to opiates are likely to have naloxone available and ready to use if someone known or suspected to be addicted to opiates is found unresponsive and not breathing normally or only gasping (see sequence in Figure 2). Victims who respond to naloxone administration should access advanced healthcare services (Class I, LOE C-EO).

### *Healthcare Provider BLS Modification: Administration of Naloxone*

*Respiratory Arrest*

For patients with known or suspected opioid overdose who have a definite pulse but no normal breathing or only gasping (ie, a respiratory arrest), in addition to providing standard BLS care, it is reasonable for appropriately trained BLS healthcare providers to administer IM or IN naloxone (Class IIa, LOE C-LD). For further information, see "Part 5: Adult Basic Life Support and Cardiopulmonary Resuscitation Quality."

*Cardiac Arrest*

Patients with no definite pulse may be in cardiac arrest or may have an undetected weak or slow pulse. These patients should be managed as cardiac arrest patients. Standard resuscitative measures should take priority over naloxone administration (Class I, LOE C-EO), with a focus on high-quality CPR (compressions plus ventilation). It may be reasonable to administer IM or IN naloxone based on the possibility that the patient is not in cardiac arrest (Class IIb, LOE C-EO). Responders should not delay access to more-advanced medical services while

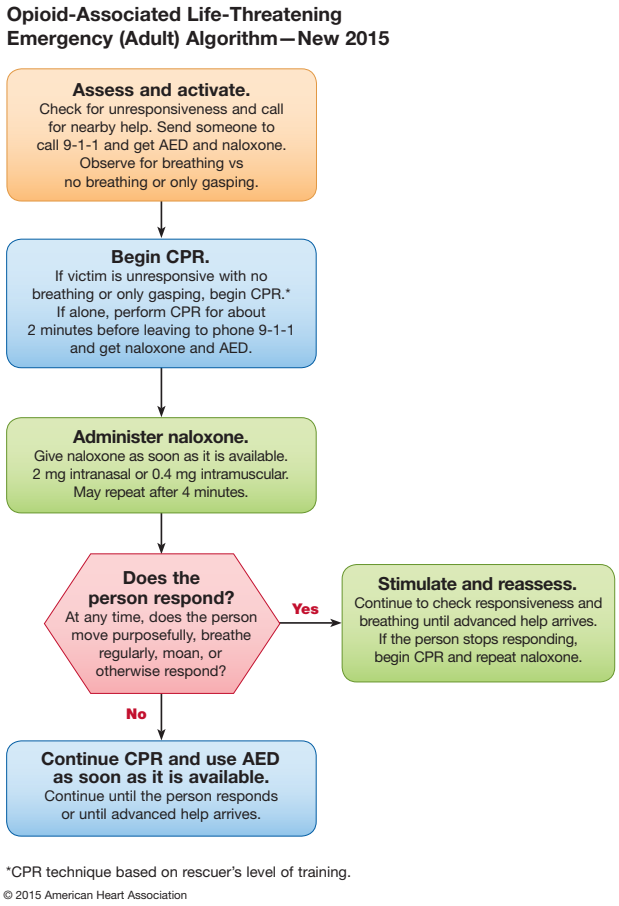


**Figure 2.** Opioid-Associated Life-Threatening Emergency (Adult) Algorithm.

awaiting the patient's response to naloxone or other interventions (Class I, LOE C-EO). Unless the patient refuses further care, victims who respond to naloxone administration should access advanced healthcare services (Class I, LOE C-EO).

### *ACLS Modification: Administration of Naloxone*

*Respiratory Arrest*

ACLS providers should support ventilation and administer naloxone to patients with a perfusing cardiac rhythm and opioid-associated respiratory arrest or severe respiratory depression. Bag-mask ventilation should be maintained until spontaneous breathing returns, and standard ACLS measures should continue if return of spontaneous breathing does not occur (Class I, LOE C-LD).

*Cardiac Arrest*

We can make no recommendation regarding the administration of naloxone in confirmed opioid-associated cardiac arrest. Patients with opioid-associated cardiac arrest are managed in accordance with standard ACLS practices.

*Observation and Post-Resuscitation Care*

After ROSC or return of spontaneous breathing, patients should be observed in a healthcare setting until the risk of recurrent opioid toxicity is low and the patient's level of consciousness and vital signs have normalized (Class I, LOE C-LD). If recurrent opioid toxicity develops, repeated small doses or an infusion of naloxone can be beneficial in healthcare settings (Class IIa, LOE C-LD).

Patients who respond to naloxone administration may develop recurrent CNS and/or respiratory depression. Although abbreviated observation periods may be adequate for patients with fentanyl, morphine, or heroin overdose,[102,109,120–123] longer periods of observation may be required to safely discharge a patient with life-threatening overdose of a long-acting or sustained-release opioid.[93,124,125]

Naloxone administration in post–cardiac arrest care may be considered in order to achieve the specific therapeutic goals of reversing the effects of long-acting opioids (Class IIb, LOE C-EO).

## Part 10.4: Role of Intravenous Lipid Emulsion Therapy in Management of Cardiac Arrest Due to Poisoning[ALS 834]

The use of ILE therapy was first developed as a treatment for cardiac arrest resulting from the local anesthetic bupivacaine.[126–128] Local anesthetics inhibit voltage at the cell membrane sodium channels, limiting action potential and the conduction of nerve signals. Local anesthetic systemic toxicity (LAST) can present with fulminant cardiovascular collapse that is refractory to standard resuscitative measures. A CNS toxicity phase (agitation evolving to frank seizures or CNS depression) may precede cardiovascular collapse. A recent review of peripheral nerve anesthetic blocks estimated the incidence of LAST equal to 0.87/1000 patients.[129] When a local anesthetic is administered, professional organizations recommend continuous neurologic and cardiovascular monitoring, dose fractionation, slow injection, concurrent use of an intravascular marker of systemic absorption (epinephrine 10 to 15 μg), and the use of ultrasound techniques.[130]

Administration of ILE creates a lipid compartment in the serum, reducing by sequestration the concentration of lipophilic medications in the tissues.[131] Administration of ILE also increases cardiac inotropy by other mechanisms.[132–134]

Over time, common use of this modality has been expanded to include poisoning by other local anesthetics and other medications.[135–138]

The 2015 ILCOR systematic review addressed the question of whether administration of lipid emulsion improves outcomes for patients who develop cardiac arrest due to drug toxicity, including that caused by local anesthetics and other drugs.

### 2015 Evidence Summary

To date, we identified no human studies that compared outcomes of patients in cardiac arrest treated with ILE plus supportive care versus supportive care alone. A small controlled trial of adults with poisoning from drugs other than local anesthetics showed a more rapid improvement in level of consciousness in the group that received ILE, but all patients survived in both groups.[139] Patients with glyphosate-surfactant herbicide ingestion treated with ILE had less hypotension and fewer arrhythmias than historic controls, but there was no difference in survival outcomes.[140] Registry studies of patients receiving ILE are difficult to interpret because of a lack of comparison groups.[141,142]

Animal studies in rats consistently show a benefit of ILE in LAST caused by bupivacaine.[137,143] Studies are less consistently positive in porcine models of LAST and from poisoning by drugs other than local anesthetics.[138] In a recent systematic review of human case reports, the majority (81/103) reported clinical improvement, such as ROSC, relief of hypotension, resolution of dysrhythmia, improved mental status, or termination of status epilepticus, after ILE administration.[138] In this review, all 21 published cases of the use of ILE to treat LAST from bupivacaine demonstrated clinical improvement after ILE administration.

Comparative dose studies are not available. The most commonly reported strategy is to use a 20% emulsion of long-chain triglycerides, giving an initial bolus of 1.5 mL/kg lean body mass over 1 minute followed by an infusion of 0.25 mL/kg per minute for 30 to 60 minutes. The bolus can be repeated once or twice as needed for persistent cardiovascular collapse; the suggested maximum total dose is 10 mL/kg over the first hour.[137,144–146] The safety of prolonged infusions (beyond 1 hour) has not been established.[147]

The most common adverse effect of ILE therapy is interference with diagnostic laboratory testing[148]; rare cases of pancreatitis[148] and pulmonary changes similar to those observed with acute respiratory distress syndrome[149] have also been reported. There appear to be complex pharmacodynamic interactions between ILE and epinephrine given during resuscitation, and in some situations, treatment with ILE alters the effectiveness of epinephrine and vasopressin in animal resuscitation studies.[150] Although some organizations recommend modification of the pharmacologic treatment of cardiac arrest after ILE administration,[151,152] there are no human data to support a modification in ACLS recommendations. More recently, concern has been raised that ILE administration may increase the absorption of lipophilic medications from the gastrointestinal tract[153] and interfere with the operation of venoarterial extracorporeal membrane oxygenation circuits.[154]

### 2015 Recommendations—New and Updated

#### *ACLS Modifications*

It may be reasonable to administer ILE, concomitant with standard resuscitative care, to patients with local anesthetic systemic toxicity and particularly to patients who have premonitory neurotoxicity or cardiac arrest due to bupivacaine toxicity (Class IIb, LOE C-EO). It may be reasonable to administer ILE to patients with other forms of drug toxicity who are failing standard resuscitative measures (Class IIb, LOE C-EO).

## Part 10.5: Cardiac Arrest During Percutaneous Coronary Intervention[ALS 479]

Cardiac arrest during PCI is rare, occurring in approximately 1.3% of catheterization procedures.[155,156] Although the risk of cardiac arrest during PCI is present in both elective and emergency procedures, the incidence is higher in emergency cases.[157]

In general, patients who develop cardiac arrest during PCI have superior outcomes to patients in cardiac arrest that occurs in other settings, including in-hospital units.[158] Many patients will respond to standard ACLS resuscitation, including high-quality CPR and rapid defibrillation. Rapid defibrillation (within 1 minute) is associated with survival to hospital discharge rates as high as 100% in this population.[159]

A subset of patients who develop cardiac arrest during PCI will require prolonged resuscitation efforts. Providing effective prolonged resuscitation in the catheterization laboratory has unique challenges, and a number of interventions and adjuncts for management of cardiac arrest during PCI have been described. Inconsistent availability and lack of comparative studies limit recommendations of one approach over another.

The 2015 ILCOR systematic review addressed the question of whether any special interventions or changes in care, compared with standard ACLS resuscitation alone, can improve outcomes in patients who develop cardiac arrest during PCI.

There are a number of mechanical devices available to provide hemodynamic support during cardiac catheterization in high-risk patients presenting with cardiogenic shock. The use of these devices in cardiogenic shock was not reviewed by ILCOR in 2015. Therefore, the *2015 AHA Guidelines Update for CPR and ECC* does not make recommendations on the use of mechanical support devices in patients presenting in cardiogenic shock who undergo PCI. Recent recommendations for the use of mechanical support devices in these situations can be found in the *2013 American College of Cardiology Foundation (ACCF)/AHA Guideline for the Management of ST-Elevation Myocardial Infarction*.[160]

### 2015 Evidence Summary

The feasibility of using mechanical CPR devices during PCI has been demonstrated in both animal[161] and human[162–165] studies. No comparative studies have examined the use of mechanical CPR devices compared with manual chest compressions during PCI procedures. However, a number of case reports[161,162,166] and case series[164,165] have reported the use of mechanical CPR devices to facilitate prolonged resuscitation in patients who have a cardiac arrest during PCI. One study demonstrated that the use of a mechanical CPR device for cardiac arrest during PCI was feasible; however, no patients survived to hospital discharge.[164] Other studies have reported good patient outcomes, including ROSC, survival to discharge, and functional outcome at hospital discharge, after use of mechanical devices in resuscitation from cardiac arrest during PCI.[161,165] Mechanical CPR devices may also allow the use of fluoroscopy during chest compressions without direct irradiation of personnel.

Patients in cardiogenic shock or with other high-risk features (eg, multivessel coronary disease) may be at increased risk for adverse outcomes during or after PCI. Ventricular assist devices, intraaortic balloon pumps (IABP), and ECPR are all rescue treatment options available to support circulation and permit completion of the PCI. Not all interventions are available or can be rapidly deployed in all centers.

Rapid initiation of ECPR or cardiopulmonary bypass is associated with good patient outcomes in patients with hemodynamic collapse and cardiac arrest in the

catheterization lab.[167–173] The use of ECPR is also feasible and associated with good outcomes when used as a bridge to coronary artery bypass grafting.[167,173–175] The combination of ECPR and IABP has been associated with increased survival when compared with IABP alone for patients who present with cardiogenic shock, including those who have a cardiac arrest while undergoing PCI.[168,172,176] Available observational studies often implement ECPR 20 to 30 minutes after cardiac arrest.[168,170]

IABP counterpulsation increases coronary perfusion, decreases myocardial oxygen demand, and improves hemodynamics in cardiogenic shock states, but it is not associated with improved patient survival in cardiogenic shock.[177–185] The role of IABP in patients who have a cardiac arrest in the catheterization laboratory is not known.

Several case series have reported on the use of emergency coronary artery bypass graft surgery after failed PCI.[186,187] In patients with cardiogenic shock or cardiac arrest and failed PCI, mechanical CPR devices and/or ECPR have been used as rescue bridges to coronary artery bypass graft. Although no comparison studies have examined the use of this therapy as an adjunct to PCI, survival to hospital discharge rates as high as 64% have been reported.[167,168,173,175]

## 2015 Recommendations—New and Updated

### *ACLS Modifications*

It may be reasonable to use mechanical CPR devices to provide chest compressions to patients in cardiac arrest during PCI (Class IIb, LOE C-EO).

It may be reasonable to use ECPR as a rescue treatment when initial therapy is failing for cardiac arrest that occurs during PCI (Class IIb, LOE C-LD). Because patients can remain on ECPR support for extended periods of time without possibility of recovery, practical and ethical considerations must be taken into account in determining which victims of cardiac arrest should receive ECPR support. Institutional guidelines should include the selection of appropriate candidates for use of mechanical support devices to ensure that these devices are used as a bridge to recovery, surgery or transplant, or other device (Class I, LOE C-EO).

Due to a lack of comparative studies, it is not possible to recommend one approach (manual CPR, mechanical CPR, or ECPR) over another when options exist.

# Disclosures

**Part 10: Special Circumstances of Resuscitation: 2015 Guidelines Update Writing Group Disclosures**

| Writing Group Member | Employment | Research Grant | Other Research Support | Speakers' Bureau/ Honoraria | Expert Witness | Ownership Interest | Consultant/ Advisory Board | Other |
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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 10 Recommendations**

| Year Last Reviewed | Topic | Recommendation | Comments |
|---|---|---|---|
| 2015 | Cardiac Arrest Associated With Pregnancy | Priorities for the pregnant woman in cardiac arrest are provision of high-quality CPR and relief of aortocaval compression (Class I, LOE C-LD). | new for 2015 |
| 2015 | Cardiac Arrest Associated With Pregnancy | If the fundus height is at or above the level of the umbilicus, manual LUD can be beneficial in relieving aortocaval compression during chest compressions (Class IIa, LOE C-LD). | new for 2015 |
| 2015 | Cardiac Arrest Associated With Pregnancy | Because immediate ROSC cannot always be achieved, local resources for a PMCD should be summoned as soon as cardiac arrest is recognized in a woman in the second half of pregnancy (Class I, LOE C-LD). | new for 2015 |
| 2015 | Cardiac Arrest Associated With Pregnancy | Systematic preparation and training are the keys to a successful response to such rare and complex events. Care teams that may be called upon to manage these situations should develop and practice standard institutional responses to allow for smooth delivery of resuscitative care (Class I, LOE C-EO). | new for 2015 |

(*Continued*)

**2015 Guidelines Update: Part 10 Recommendations, *Continued***

| Year Last Reviewed | Topic | Recommendation | Comments |
|---|---|---|---|
| 2015 | Cardiac Arrest Associated With Pregnancy | During cardiac arrest, if the pregnant woman with a fundus height at or above the umbilicus has not achieved ROSC with usual resuscitation measures plus manual LUD, it is advisable to prepare to evacuate the uterus while resuscitation continues (Class I, LOE C-LD). | new for 2015 |
| 2015 | Cardiac Arrest Associated With Pregnancy | In situations such as nonsurvivable maternal trauma or prolonged pulselessness, in which maternal resuscitative efforts are obviously futile, there is no reason to delay performing PMCD (Class I, LOE C-LD). | new for 2015 |
| 2015 | Cardiac Arrest Associated With Pregnancy | PMCD should be considered at 4 minutes after onset of maternal cardiac arrest or resuscitative efforts (for the unwitnessed arrest) if there is no ROSC (Class IIa, LOE C-EO). | updated for 2015 |
| 2015 | Cardiac Arrest Associated With Pulmonary Embolism | In patients with confirmed PE as the precipitant of cardiac arrest, thrombolysis, surgical embolectomy, and mechanical embolectomy are reasonable emergency treatment options (Class IIa, LOE C-LD). | new for 2015 |
| 2015 | Cardiac Arrest Associated With Pulmonary Embolism | Thrombolysis can be beneficial even when chest compressions have been provided (Class IIa, LOE C-LD). | new for 2015 |
| 2015 | Cardiac Arrest Associated With Pulmonary Embolism | Thrombolysis may be considered when cardiac arrest is suspected to be caused by PE (Class IIb, LOE C-LD). | updated for 2015 |
| 2015 | Cardiac or Respiratory Arrest Associated With Opioid Overdose | It is reasonable to provide opioid overdose response education, either alone or coupled with naloxone distribution and training, to persons at risk for opioid overdose (Class IIa, LOE C-LD). | new for 2015 |
| 2015 | Cardiac or Respiratory Arrest Associated With Opioid Overdose | It is reasonable to base this training on first aid and non–healthcare provider BLS recommendations rather than on more advanced practices intended for healthcare providers (Class IIa, LOE C-EO). | new for 2015 |
| 2015 | Cardiac or Respiratory Arrest Associated With Opioid Overdose | Empiric administration of IM or IN naloxone to all unresponsive opioid-associated life-threatening emergency patients may be reasonable as an adjunct to standard first aid and non–healthcare provider BLS protocols (Class IIb, LOE C-EO). | new for 2015 |
| 2015 | Cardiac or Respiratory Arrest Associated With Opioid Overdose | Victims who respond to naloxone administration should access advanced healthcare services (Class I, LOE C-EO). | new for 2015 |
| 2015 | Cardiac or Respiratory Arrest Associated With Opioid Overdose | For patients with known or suspected opioid overdose who have a definite pulse but no normal breathing or only gasping (ie, a respiratory arrest), in addition to providing standard BLS care, it is reasonable for appropriately trained BLS healthcare providers to administer IM or IN naloxone (Class IIa, LOE C-LD). | new for 2015 |
| 2015 | Cardiac or Respiratory Arrest Associated With Opioid Overdose | Standard resuscitative measures should take priority over naloxone administration (Class I, LOE C-EO), with a focus on high-quality CPR (compressions plus ventilation). | new for 2015 |
| 2015 | Cardiac or Respiratory Arrest Associated With Opioid Overdose | It may be reasonable to administer IM or IN naloxone based on the possibility that the patient is not in cardiac arrest (Class IIb, LOE C-EO). | new for 2015 |
| 2015 | Cardiac or Respiratory Arrest Associated With Opioid Overdose | Responders should not delay access to more-advanced medical services while awaiting the patient's response to naloxone or other interventions (Class I, LOE C-EO). | new for 2015 |
| 2015 | Cardiac or Respiratory Arrest Associated With Opioid Overdose | Unless the patient refuses further care, victims who respond to naloxone administration should access advanced healthcare services (Class I, LOE C-EO). | new for 2015 |
| 2015 | Cardiac or Respiratory Arrest Associated With Opioid Overdose | Bag-mask ventilation should be maintained until spontaneous breathing returns, and standard ACLS measures should continue if return of spontaneous breathing does not occur (Class I, LOE C-LD). | new for 2015 |
| 2015 | Cardiac or Respiratory Arrest Associated With Opioid Overdose | After ROSC or return of spontaneous breathing, patients should be observed in a healthcare setting until the risk of recurrent opioid toxicity is low and the patient's level of consciousness and vital signs have normalized (Class I, LOE C-LD). | new for 2015 |
| 2015 | Cardiac or Respiratory Arrest Associated With Opioid Overdose | If recurrent opioid toxicity develops, repeated small doses or an infusion of naloxone can be beneficial in healthcare settings (Class IIa, LOE C-LD). | new for 2015 |
| 2015 | Cardiac or Respiratory Arrest Associated With Opioid Overdose | Naloxone administration in post–cardiac arrest care may be considered in order to achieve the specific therapeutic goals of reversing the effects of long-acting opioids (Class IIb, LOE C-EO). | new for 2015 |

(*Continued*)

**2015 Guidelines Update: Part 10 Recommendations, *Continued***

| Year Last Reviewed | Topic | Recommendation | Comments |
|---|---|---|---|
| 2015 | Role of Intravenous Lipid Emulsion Therapy in Management of Cardiac Arrest Due to Poisoning | It may be reasonable to administer ILE, concomitant with standard resuscitative care, to patients with local anesthetic systemic toxicity and particularly to patients who have premonitory neurotoxicity or cardiac arrest due to bupivacaine toxicity (Class IIb, LOE C-EO). | updated for 2015 |
| 2015 | Role of Intravenous Lipid Emulsion Therapy in Management of Cardiac Arrest Due to Poisoning | It may be reasonable to administer ILE to patients with other forms of drug toxicity who are failing standard resuscitative measures (Class IIb, LOE C-EO). | new for 2015 |
| 2015 | Cardiac Arrest During Percutaneous Coronary Intervention | It may be reasonable to use mechanical CPR devices to provide chest compressions to patients in cardiac arrest during PCI (Class IIb, LOE C-EO). | updated for 2015 |
| 2015 | Cardiac Arrest During Percutaneous Coronary Intervention | It may be reasonable to use ECPR as a rescue treatment when initial therapy is failing for cardiac arrest that occurs during PCI (Class IIb, LOE C-LD). | new for 2015 |
| 2015 | Cardiac Arrest During Percutaneous Coronary Intervention | Institutional guidelines should include the selection of appropriate candidates for use of mechanical support devices to ensure that these devices are used as a bridge to recovery, surgery or transplant, or other device (Class I, LOE C-EO). | new for 2015 |
| The following recommendations were not reviewed in 2015. For more information, see the *2010 AHA Guidelines for CPR and ECC*, "Part 12: Cardiac Arrest in Special Situations." | | | |
| 2010 | Cardiac Arrest Associated With Asthma | Therefore, since the effects of auto-PEEP in an asthmatic patient with cardiac arrest are likely quite severe, a ventilation strategy of low respiratory rate and tidal volume is reasonable (Class IIa, LOE C). | not reviewed in 2015 |
| 2010 | Cardiac Arrest Associated With Asthma | During arrest a brief disconnection from the bag mask or ventilator may be considered, and compression of the chest wall to relieve air-trapping can be effective (Class IIa, LOE C). | not reviewed in 2015 |
| 2010 | Cardiac Arrest Associated With Asthma | For all asthmatic patients with cardiac arrest, and especially for patients in whom ventilation is difficult, the possible diagnosis of a tension pneumothorax should be considered and treated (Class I, LOE C). | not reviewed in 2015 |
| 2010 | Cardiac Arrest Associated With Anaphylaxis | Given the potential for the rapid development of oropharyngeal or laryngeal edema, immediate referral to a health professional with expertise in advanced airway placement is recommended (Class I, LOE C). | not reviewed in 2015 |
| 2010 | Cardiac Arrest Associated With Anaphylaxis | Epinephrine should be administered early by IM injection to all patients with signs of a systemic allergic reaction, especially hypotension, airway swelling, or difficulty breathing (Class I, LOE C). | not reviewed in 2015 |
| 2010 | Cardiac Arrest Associated With Anaphylaxis | The recommended dose is 0.2 to 0.5 mg (1:1000) IM to be repeated every 5 to 15 minutes in the absence of clinical improvement (Class I, LOE C). | not reviewed in 2015 |
| 2010 | Cardiac Arrest Associated With Anaphylaxis | In both anaphylaxis and cardiac arrest the immediate use of an epinephrine autoinjector is recommended if available (Class I, LOE C). | not reviewed in 2015 |
| 2010 | Cardiac Arrest Associated With Anaphylaxis | Planning for advanced airway management, including a surgical airway, is recommended (Class I, LOE C). | not reviewed in 2015 |
| 2010 | Cardiac Arrest Associated With Anaphylaxis | Vasogenic shock from anaphylaxis may require aggressive fluid resuscitation (Class IIa, LOE C). | not reviewed in 2015 |
| 2010 | Cardiac Arrest Associated With Anaphylaxis | When an IV line is in place, it is reasonable to consider the IV route as an alternative to IM administration of epinephrine in anaphylactic shock (Class IIa, LOE C). | not reviewed in 2015 |
| 2010 | Cardiac Arrest Associated With Anaphylaxis | Because fatal overdose of epinephrine has been reported, close hemodynamic monitoring is recommended (Class I, LOE B). | not reviewed in 2015 |
| 2010 | Cardiac Arrest Associated With Anaphylaxis | IV infusion of epinephrine is a reasonable alternative to IV boluses for treatment of anaphylaxis in patients not in cardiac arrest (Class IIa, LOE C) | not reviewed in 2015 |
| 2010 | Cardiac Arrest Associated With Anaphylaxis | Alternative vasoactive drugs (vasopressin, norepinephrine, methoxamine, and metaraminol) may be considered in cardiac arrest secondary to anaphylaxis that does not respond to epinephrine (Class IIb, LOE C). | not reviewed in 2015 |
| 2010 | Cardiac Arrest Associated With Anaphylaxis | Adjuvant use of antihistamines (H1 and H2 antagonist), inhaled β-adrenergic agents, and IV corticosteroids has been successful in management of the patient with anaphylaxis and may be considered in cardiac arrest due to anaphylaxis (Class IIb, LOE C). | not reviewed in 2015 |
| 2010 | Cardiac Arrest Associated With Anaphylaxis | Cardiopulmonary bypass has been successful in isolated case reports of anaphylaxis followed by cardiac arrest. Use of these advanced techniques may be considered in clinical situations where the required professional skills and equipment are immediately available (Class IIb, LOE C). | not reviewed in 2015 |

(*Continued*)

**2015 Guidelines Update: Part 10 Recommendations, *Continued***

| Year Last Reviewed | Topic | Recommendation | Comments |
|---|---|---|---|
| 2010 | Cardiac Arrest Associated With Pregnancy | Bag-mask ventilation with 100% oxygen before intubation is especially important in pregnancy (Class IIa, LOE B). | not reviewed in 2015 |
| 2010 | Cardiac Arrest Associated With Pregnancy | If internal or external fetal monitors are attached during cardiac arrest in a pregnant woman, it is reasonable to remove them (Class IIb, LOE C). | not reviewed in 2015 |
| 2010 | Cardiac Arrest Associated With Pregnancy | Team planning should be done in collaboration with the obstetric, neonatal, emergency, anesthesiology, intensive care, and cardiac arrest services (Class I, LOE C). | not reviewed in 2015 |
| 2010 | Cardiac Arrest Associated With Pregnancy | During therapeutic hypothermia of the pregnant patient, it is recommended that the fetus be continuously monitored for bradycardia as a potential complication, and obstetric and neonatal consultation should be sought (Class I, LOE C). | not reviewed in 2015 |
| 2010 | Cardiac Arrest Associated With Pulmonary Embolism | In patients with cardiac arrest and without known PE, routine fibrinolytic treatment given during CPR shows no benefit and is not recommended (Class III, LOE A). | not reviewed in 2015 |
| 2010 | Cardiac Arrest Associated With Life-Threatening Electrolyte Disturbances | When cardiac arrest occurs secondary to hyperkalemia, it may be reasonable to administer adjuvant IV therapy as outlined above for cardiotoxicity in addition to standard ACLS (Class IIb, LOE C). | not reviewed in 2015 |
| 2010 | Cardiac Arrest Associated With Life-Threatening Electrolyte Disturbances | The effect of bolus administration of potassium for cardiac arrest suspected to be secondary to hypokalemia is unknown and ill advised (Class III, LOE C). | not reviewed in 2015 |
| 2010 | Cardiac Arrest Associated With Life-Threatening Electrolyte Disturbances | Administration of calcium (calcium chloride [10%] 5 to 10 mL or calcium gluconate [10%] 15 to 30 mL IV over 2 to 5 minutes) may be considered during cardiac arrest associated with hypermagnesemia (Class IIb, LOE C). | not reviewed in 2015 |
| 2010 | Cardiac Arrest Associated With Life-Threatening Electrolyte Disturbances | For cardiotoxicity and cardiac arrest, IV magnesium 1 to 2 g of $MgSO_4$ bolus IV push is recommended (Class I, LOE C). | not reviewed in 2015 |
| 2010 | Cardiac Arrest Associated With Life-Threatening Electrolyte Disturbances | Empirical use of calcium (calcium chloride [10%] 5 to 10 mL OR calcium gluconate [10%] 15 to 30 mL IV over 2 to 5 minutes) may be considered when hyperkalemia or hypermagnesemia is suspected as the cause of cardiac arrest (Class IIb, LOE C). | not reviewed in 2015 |
| 2010 | Cardiac Arrest Associated With Toxic Ingestions | The administration of flumazenil to patients with undifferentiated coma confers risk and is not recommended (Class III, LOE B). | not reviewed in 2015 |
| 2010 | Cardiac Arrest Associated With Toxic Ingestions | The recommended dose of glucagon is a bolus of 3 to 10 mg, administered slowly over 3 to 5 minutes, followed by an infusion of 3 to 5 mg/h (0.05 to 0.15 mg/kg followed by an infusion of 0.05 to 0.10 mg/kg per hour) (Class IIb, LOE C). | not reviewed in 2015 |
| 2010 | Cardiac Arrest Associated With Toxic Ingestions | Administration of high-dose insulin in patients with shock refractory to other measures may be considered (Class IIb, LOE C). | not reviewed in 2015 |
| 2010 | Cardiac Arrest Associated With Toxic Ingestions | Administration of calcium in patients with shock refractory to other measures may be considered (Class IIb, LOE C). | not reviewed in 2015 |
| 2010 | Cardiac Arrest Associated With Toxic Ingestions | High-dose insulin, in the doses listed in the β-blocker section above, may be effective for restoring hemodynamic stability and improving survival in the setting of severe cardiovascular toxicity associated with toxicity from a calcium channel blocker overdose (Class IIb, LOE B). | not reviewed in 2015 |
| 2010 | Cardiac Arrest Associated With Toxic Ingestions | Administration of calcium in patients with shock refractory to other measures may be considered (Class IIb, LOE C). | not reviewed in 2015 |
| 2010 | Cardiac Arrest Associated With Toxic Ingestions | Antidigoxin Fab antibodies should be administered to patients with severe life-threatening cardiac glycoside toxicity (Class I, LOE B). | not reviewed in 2015 |
| 2010 | Cardiac Arrest Associated With Toxic Ingestions | It may be reasonable to try agents that have shown efficacy in the management of acute coronary syndrome in patients with severe cardiovascular toxicity. β-Blockers (phentolamine), benzodiazepines (lorazepam, diazepam), calcium channel blockers (verapamil), morphine, and sublingual nitroglycerin may be used as needed to control hypertension, tachycardia, and agitation (Class IIb, LOE B). | not reviewed in 2015 |
| 2010 | Cardiac Arrest Associated With Toxic Ingestions | The available data do not support the use of 1 agent over another in the treatment of cardiovascular toxicity due to cocaine (Class IIb, LOE B). | not reviewed in 2015 |
| 2010 | Cardiac Arrest Associated With Toxic Ingestions | For cocaine-induced hypertension or chest discomfort, benzodiazepines, nitroglycerin, and/or morphine can be beneficial (Class IIa, LOE B). | not reviewed in 2015 |

(*Continued*)

**2015 Guidelines Update: Part 10 Recommendations, *Continued***

| Year Last Reviewed | Topic | Recommendation | Comments |
|---|---|---|---|
| 2010 | Cardiac Arrest Associated With Toxic Ingestions | Although contradictory evidence exists, current recommendations are that pure β-blocker medications in the setting of cocaine are not indicated (Class IIb, LOE C). | not reviewed in 2015 |
| 2010 | Cardiac Arrest Associated With Toxic Ingestions | Administration of sodium bicarbonate for cardiac arrest due to cyclic antidepressant overdose may be considered (Class IIb, LOE C). | not reviewed in 2015 |
| 2010 | Cardiac Arrest Associated With Toxic Ingestions | Sodium bicarbonate boluses of 1 mL/kg may be administered as needed to achieve hemodynamic stability (adequate mean arterial blood pressure and perfusion) and QRS narrowing (Class IIb, LOE C). | not reviewed in 2015 |
| 2010 | Cardiac Arrest Associated With Toxic Ingestions | Because hyperbaric oxygen therapy appears to confer little risk, the available data suggest that hyperbaric oxygen therapy may be helpful in treatment of acute carbon monoxide poisoning in patients with severe toxicity (Class IIb, LOE C). | not reviewed in 2015 |
| 2010 | Cardiac Arrest Associated With Toxic Ingestions | Based on the best evidence available, a treatment regimen of 100% oxygen and hydroxocobalamin, with or without sodium thiosulfate, is recommended (Class I, LOE B). | not reviewed in 2015 |
| 2010 | Cardiac Arrest in Accidental Hypothermia | It may be reasonable to perform further defibrillation attempts according to the standard BLS algorithm concurrent with rewarming strategies (Class IIb, LOE C). | not reviewed in 2015 |
| 2010 | Cardiac Arrest in Accidental Hypothermia | It may be reasonable to consider administration of a vasopressor during cardiac arrest according to the standard ACLS algorithm concurrent with rewarming strategies (Class IIb, LOE C). | not reviewed in 2015 |
| 2010 | Cardiac Arrest in Avalanche Victims | Full resuscitative measures, including extracorporeal rewarming when available, are recommended for all avalanche victims without the characteristics outlined above that deem them unlikely to survive or with any obvious lethal traumatic injury (Class I, LOE C). | not reviewed in 2015 |
| 2010 | Drowning | All victims of drowning who require any form of resuscitation (including rescue breathing alone) should be transported to the hospital for evaluation and monitoring, even if they appear to be alert and demonstrate effective cardiorespiratory function at the scene (Class I, LOE C). | not reviewed in 2015 |
| 2010 | Drowning | Routine stabilization of the cervical spine in the absence of circumstances that suggest a spinal injury is not recommended (Class III, LOE B). | not reviewed in 2015 |
| 2010 | Drowning | The routine use of abdominal thrusts or the Heimlich maneuver for drowning victims is not recommended (Class III, LOE C). | not reviewed in 2015 |
| 2010 | Cardiac Arrest During Percutaneous Coronary Intervention | It is reasonable to use cough CPR during PCI (Class IIa, LOE C). | not reviewed in 2015 |
| 2010 | Cardiac Arrest Caused by Cardiac Tamponade | In the arrest setting, in the absence of echocardiography, emergency pericardiocentesis without imaging guidance can be beneficial (Class IIa, LOE C). | not reviewed in 2015 |
| 2010 | Cardiac Arrest Caused by Cardiac Tamponade | Emergency department thoracotomy may improve survival compared with pericardiocentesis in patients with pericardial tamponade secondary to trauma who are in cardiac arrest or who are prearrest, especially if gross blood causes clotting that blocks a pericardiocentesis needle (Class IIb, LOE C). | not reviewed in 2015 |
| 2010 | Cardiac Arrest Following Cardiac Surgery | For patients with cardiac arrest following cardiac surgery, it is reasonable to perform resternotomy in an appropriately staffed and equipped intensive care unit (Class IIa, LOE B). | not reviewed in 2015 |
| 2010 | Cardiac Arrest Following Cardiac Surgery | Despite rare case reports describing damage to the heart possibly due to external chest compressions, chest compressions should not be withheld if emergency resternotomy is not immediately available (Class IIa, LOE C). | not reviewed in 2015 |

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KEY WORDS: cardiac arrest ■ defibrillation ■ emergency

# Part 10: Special Circumstances of Resuscitation: 2015 American Heart Association Guidelines Update for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care

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# Correction to: Part 10: Special Circumstances of Resuscitation: 2015 American Heart Association Guidelines Update for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care

In the article by Lavonas et al "Part 10: Special Circumstances of Resuscitation: 2015 American Heart Association Guidelines Update for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care," which published online October 15, 2015, and appeared in the November 3, 2015, issue of the journal (*Circulation.* 2015;132[suppl 2]:S501–S518. DOI: 10.1161/CIR.0000000000000264), a correction was needed.

1. On page S517, in the Reference section, reference 138 read, "138. Cao H, Zhou X, Zhang J, Huang X, Zhai Y, Zhang X, Chu L. Hydrogen sulfide protects against bleomycin-induced pulmonary fibrosis in rats by inhibiting NF-κB expression and regulating Th1/Th2 balance. *Toxicol Lett.* 2014;224:387–394. doi: 10.1016/j.toxlet.2013.11.008." It has been replaced with, "Cao D, Heard K, Foran M, Koyfman A. Intravenous lipid emulsion in the emergency department: a systematic review of the literature. *J Emerg Med.* 2015;48:387–397. doi:10.1016/j.jemermed.2014.10.009."

This correction has been made to the current online version of the article, which is available at http://circ.ahajournals.org/content/132/18_suppl_2/S501.

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