Part 6: Alternative Techniques and Ancillary Devices for Cardiopulmonary Resuscitation

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

Key Words: cardiac arrest   cardiopulmonary resuscitation   emergency   ventricular fibrillation

1 Highlights

Summary of Key Issues and Major Changes

Conventional CPR consisting of manual chest compressions interspersed with rescue breaths is inherently inefficient with respect to generating significant cardiac output. A variety of alternatives and adjuncts to conventional CPR have been developed with the aim of enhancing cardiac output resuscitation from cardiac arrest. Since the 2010 Guidelines were published, a number of clinical trials have provided new data on the effectiveness of these alternatives.

Compared with conventional CPR, many of these techniques and devices require specialized equipment and training. When rescuers or healthcare systems are considering implementation, it must be noted that some techniques and devices have been tested only in highly selected subgroups of cardiac arrest patients.

- The routine use of the impedance threshold device (ITD) as an adjunct to conventional CPR is not recommended.
- A recent randomized controlled trial suggests that the use of the ITD plus active compression-decompression CPR is associated with improved neurologically intact survival for patients with OHCA.
- The routine use of mechanical chest compression devices is not recommended, but special settings where this technology may be useful are identified.
- The use of ECPR may be considered for selected patients in settings where a reversible cause of cardiac arrest is suspected.

Impedance Threshold Devices

 2015 (Updated): The routine use of the ITD as an adjunct during conventional CPR is not recommended. The combination of ITD with active compression-decompression CPR may be a reasonable alternative to conventional CPR in settings with available equipment and properly trained personnel.

 2010 (Old): The use of the ITD may be considered by trained personnel as a CPR adjunct in adult cardiac arrest.

 Why: Two large randomized controlled trials have provided new information about the use of the ITD in OHCA. One large multicenter randomized clinical trial failed to demonstrate any improvement associated with the use of an ITD (compared with a sham device) as an adjunct to conventional CPR. Another clinical trial demonstrated a benefit with the use of active compression-decompression CPR plus an ITD when compared with conventional CPR and no ITD. However, confidence intervals around the primary outcome point estimate were very broad, and there is a high risk of bias on the basis of co-intervention (the group receiving active compression-decompression CPR plus the ITD also had CPR delivered using CPR quality feedback devices, while the control arm did not have the use of such feedback devices).

Mechanical Chest Compression Devices

 2015 (Updated): The evidence does not demonstrate a benefit with the use of mechanical piston devices for chest compressions versus manual chest compressions in patients with cardiac arrest. Manual chest compressions remain the standard of care for the treatment of cardiac arrest. However, such a device may be a reasonable alternative to conventional CPR in specific settings where the delivery of high-quality manual compressions may be challenging or dangerous for the provider (eg, limited rescuers available, prolonged CPR,

CPR during hypothermic cardiac arrest, CPR in a moving ambulance, CPR in the angiography suite, CPR during preparation for ECPR).

 2010 (Old): Mechanical piston devices may be considered for use by properly trained personnel in specific settings for the treatment of adult cardiac arrest in circumstances (e.g., during diagnostic and interventional procedures) that make manual resuscitation difficult. The load-distributing band may be considered for use by properly trained personnel in specific settings for the treatment of cardiac arrest.

 Why: Three large randomized controlled trials comparing mechanical chest compression devices have not demonstrated improved outcomes for patients with OHCA when compared with manual chest compressions. For this reason, manual chest compressions remain the standard of care.

Extracorporeal Techniques and Invasive Perfusion Devices

 2015 (Updated): ECPR may be considered an alternative to conventional CPR for select patients who have a cardiac arrest and for whom the suspected etiology of the cardiac arrest is potentially reversible.

 2010 (Old): There was insufficient evidence to recommend the routine use of ECPR for patients in cardiac arrest. However, in settings where ECPR is readily available, it may be considered when the time without blood flow is brief and the condition leading to the cardiac arrest is reversible (e.g., accidental hypothermia, drug intoxication) or amenable to heart transplantation (e.g., myocarditis) or revascularization (eg, acute myocardial infarction).

 Why: The term *extracorporeal* CPR is used to describe the initiation of extracorporeal circulation and oxygenation during the resuscitation of a patient in cardiac arrest. ECPR involves the emergency cannulation of a large vein and artery (e.g., femoral vessels). The goal of ECPR is to support patients in cardiac arrest while potentially reversible conditions are treated. ECPR is a complex process that requires a highly trained team, specialized equipment, and multidisciplinary support within the local healthcare system. There are no clinical trials on ECPR, and available published series have used rigorous inclusion and exclusion criteria to select patients for ECPR. Although these inclusion criteria are highly variable, most included only patients aged 18 to 75 years with limited comorbidities, with arrest of cardiac origin, after conventional CPR for more than 10 minutes without ROSC. These inclusion criteria should be considered in a provider's selection of potential candidates for ECPR.

2 Introduction - Updated

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

Conventional cardiopulmonary resuscitation (CPR) consisting of manual chest compressions with rescue breaths is inherently inefficient with respect to generating cardiac output. A variety of alternatives and adjuncts to conventional CPR have been developed, with the aim of enhancing perfusion during resuscitation from cardiac arrest. Since the publication of the *2010 American Heart Association* (AHA) *Guidelines for CPR and Emergency Cardiovascular Care* (ECC), a number of clinical trials have provided additional data on the effectiveness of these alternatives and adjuncts. Compared with conventional CPR, many of these techniques and devices require specialized equipment and training. Some have only been tested in highly selected subgroups of cardiac arrest patients; this context must be considered when rescuers or healthcare systems are considering implementation.

The 2010 Guidelines add these cautions:

2.1 Methodology - Updated

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

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

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

To create the *2015 AHA Guidelines Update for CPR and ECC*, the AHA formed 15 writing groups, with careful attention to manage conflicts of interest, to assess the ILCOR treatment recommendations, and to write AHA Guidelines and treatment recommendations by using the AHA Class of Recommendation and Level of Evidence (LOE) system. The recommendations made in the *2015 AHA Guidelines Update for CPR and ECC* are informed by the ILCOR recommendations and GRADE classification, in the context of the delivery of medical care in North America. Throughout the online version of this publication, live links are provided so the reader can connect directly to the systematic reviews on the ILCOR Scientific Evidence Evaluation and Review System (SEERS) website. These links are indicated by a superscript combination of letters and numbers (eg, ALS 579). We encourage readers to use the links and review the evidence and appendixes, such as the GRADE tables. For further information, please see Part 2 of this supplement, "Evidence Evaluation and Management of Conflicts of Interest."

The following CPR techniques and devices were last reviewed in 2010 [1,2]: open-chest CPR, interposed abdominal compression, "cough" CPR, prone CPR, precordial thump, percussion pacing, and devices to assist ventilation. The reader is referred to the 2010 Guidelines for details of those recommendations. A listing of all of the recommendations in this 2015 Guidelines Update and the recommendations from "Part 7: CPR Techniques and Devices" of the 2010 Guidelines can be found in the Appendix. The 2010 recommendations are included below in this Web-based Integrated Guideline document.

3 CPR Techniques

3.1 Open-Chest CPR

In open-chest CPR the heart is accessed through a thoracotomy (typically created through the 5th left intercostal space) and compression is performed using the thumb and fingers, or with the palm and extended fingers against the sternum. Use of this technique generates forward blood flow and coronary perfusion pressure that typically exceed those generated by closed chest compressions.

There are few human studies comparing open-chest CPR to conventional CPR in cardiac arrest and no prospective randomized trials. Several studies of open-chest CPR have demonstrated improved coronary perfusion pressure and/or return of spontaneous circulation (ROSC) for both the in-hospital (eg, following cardiac surgery)[7-9] and out-of-hospital environments. [10-13]

Several small case series of cardiac arrest patients treated with thoracotomy and open-chest CPR after blunt [14,15] or penetrating trauma[15-17] reported survivors with mild or no neurological deficit.

There is insufficient evidence of benefit or harm to recommend the routine use of open-chest CPR.

However, open-chest CPR can be useful if cardiac arrest develops during surgery when the chest or abdomen is already open, or in the early postoperative period after cardiothoracic surgery. *(Class IIa, LOE C2)*

A resuscitative thoracotomy to facilitate open-chest CPR may be considered in very select circumstances of adults and children with out-of-hospital cardiac arrest from penetrating trauma with short transport times to a trauma facility.[18,19](Class IIb, LOE C)

3.2 Interposed Abdominal Compression-CPR

The interposed abdominal compression (IAC)-CPR is a 3-rescuer technique (an abdominal compressor plus the chest compressor and the rescuer providing ventilations) that includes conventional chest compressions combined with alternating abdominal compressions. The dedicated rescuer who provides manual abdominal compressions will compress the abdomen midway between the xiphoid and the umbilicus during the relaxation phase of chest compression. Hand position, depth, rhythm, and rate of abdominal compressions are similar to those for chest compressions and the force required is similar to that used to palpate the abdominal aorta. In most reports, an endotracheal tube is placed before or shortly after initiation of IAC-CPR. IAC-CPR increases diastolic aortic pressure and venous return, resulting in improved coronary perfusion pressure and blood flow to other vital organs.

In 2 randomized in-hospital trials, IAC-CPR performed by trained rescuers improved short-term survival[20] and survival to hospital discharge[21] compared with conventional CPR for adult cardiac arrest. The data from these studies were combined in 2 positive meta-analyses.[22,23] However, 1 randomized controlled trial of adult out-of-hospital cardiac arrest[24] did not show any survival advantage to IAC-CPR. Although there were no complications reported in adults,[22] 1 pediatric case report[25] documented traumatic pancreatitis following IAC-CPR.

IAC-CPR may be considered during in-hospital resuscitation when sufficient personnel trained in its use are available. *(Class IIb, LOE B)*

There is insufficient evidence to recommend for or against the use of IAC-CPR in the out-of-hospital setting or in children.

3.3 "Cough" CPR

"Cough" CPR describes the use of forceful voluntary coughs every 1 to 3 seconds in conscious patients shortly after the onset of a witnessed nonperfusing cardiac rhythm in a controlled environment such as the cardiac catheterization laboratory. Coughing episodically increases the intrathoracic pressure and can generate systemic blood pressures higher than those usually generated by conventional chest compressions,[26,27] allowing patients to maintain consciousness[26-29] for a brief arrhythmic interval (up to 92 seconds documented in humans).[28]

"Cough" CPR has been reported exclusively in awake, monitored patients (predominantly in the cardiac catheterization laboratory) when arrhythmic cardiac arrest can be anticipated, the patient remains conscious and can be instructed before and coached during the event, and cardiac activity can be promptly restored.[26-36] However, not all victims are able to produce hemodynamically effective coughs.[30]

"Cough" CPR is not useful for unresponsive victims and should not be taught to lay rescuers. "Cough" CPR may be considered in settings such as the cardiac catheterization laboratory for conscious, supine, and monitored patients if the patient can be instructed and coached to cough forcefully every 1 to 3 seconds during the initial seconds of an arrhythmic cardiac arrest. It should not delay definitive treatment. *(Class IIb, LOE C)*

3.4 Prone CPR

When the patient cannot be placed in the supine position, it may be reasonable for rescuers to provide CPR with the patient in the prone position, particularly in hospitalized patients with an advanced airway in place.[37-40] *(Class IIb, LOE C)*

3.5 Precordial Thump

A precordial thump has been reported to convert ventricular tachyarrhythmias in 1 study with concurrent controls,[41] single-patient case reports, and small case series.[42-46] However, 2 larger case series found that the precordial thump was ineffective in 79 (98.8%) of 80 cases[47] and in 153 (98.7%) of 155 cases of malignant

ventricular arrhythmias.[48] Case reports and case series[49-51] have documented complications associated with precordial thump including sternal fracture, osteomyelitis, stroke, and triggering of malignant arrhythmias in adults and children.

The precordial thump should not be used for unwitnessed out-of-hospital cardiac arrest. (Class III, LOE C)

The precordial thump may be considered for patients with witnessed, monitored, unstable ventricular tachycardia including pulseless VT if a defibrillator is not immediately ready for use, but it should not delay CPR and shock delivery. (Class IIb, LOE C)

There is insufficient evidence to recommend for or against the use of the precordial thump for witnessed onset of asystole.

3.6 Percussion Pacing

Percussion (eg, fist) pacing refers to the use of regular, rhythmic and forceful percussion of the chest with the rescuer's fist in an attempt to pace the myocardium. There is little evidence supporting fist or percussion pacing in cardiac arrest based on 6 single-patient case reports[52-57] and a moderate-sized case series.[58] There is insufficient evidence to recommend percussion pacing during typical attempted resuscitation from cardiac arrest.

4 CPR Devices - Updated

4.1 Devices to Assist Ventilation

4.1.1 Automatic and Mechanical Transport Ventilators

4.1.1.1 Automatic Transport Ventilators

There are very few studies evaluating the use of automatic transport ventilators (ATVs) during attempted resuscitation in patients with endotracheal intubation.

During prolonged resuscitation efforts, the use of an ATV (pneumatically powered and time- or pressure-cycled) may provide ventilation and oxygenation similar to that possible with the use of a manual resuscitation bag, while allowing the Emergency Medical Services (EMS) team to perform other tasks.[59, 60] (Class IIb, LOE C)

Disadvantages of ATVs include the need for an oxygen source and a power source. Thus, providers should always have a bag-mask device available for manual backup. For additional information regarding support of airway and ventilation in the adult, see "Part 7:Adult Advanced Cardiovascular Life Support."

4.1.1.2 Manually Triggered, Oxygen-Powered, Flow-Limited Resuscitators

In a study of 104 anesthetized nonarrest patients without an advanced airway in place (ie, no endotracheal tube; patients were ventilated through a mask), patients ventilated by firefighters with manually triggered, oxygen-powered, flow-limited resuscitators had less gastric inflation than those ventilated with a bag-mask device.[61]

Manually triggered, oxygen-powered, flow-limited resuscitators may be considered for the management of patients who do not have an advanced airway in place and for whom a mask is being used for ventilation during CPR. (Class IIb, LOE C)

Rescuers should avoid using the automatic mode of the oxygen-powered, flow-limited resuscitator during CPR because it may generate high positive end-expiratory pressure (PEEP) that may impede venous return during chest compressions and compromise forward blood flow.[62] (Class III, LOE C)

4.2 Devices to Support Circulation - Updated

4.2.1 Active Compression-Decompression CPR

Active compression-decompression CPR (ACD-CPR) is performed with a device that includes a suction cup to actively lift the anterior chest during decompression. The application of external negative suction during the decompression phase of CPR creates negative intrathoracic pressure and thus potentially enhances venous return to the heart. When used, the device is positioned at midsternum on the chest.

Results from the use of ACD-CPR have been mixed. In several studies[63-68] ACD-CPR improved ROSC and short-term survival compared with conventional CPR. Of these studies, 3 showed improvement in neurologically intact survival.[63,66,67] In contrast, 1 Cochrane meta-analysis of 10 studies involving both in-hospital arrest (826 patients) and out-of-hospital arrest (4162 patients)[69] and several other controlled trials[70-76] comparing ACD-CPR to conventional CPR showed no difference in ROSC or survival. The meta-analysis[69] did not find any increase in ACD-CPR–related complications.

There is insufficient evidence to recommend for or against the routine use of ACD-CPR. ACD-CPR may be considered for use when providers are adequately trained and monitored. (Class IIb, LOE B)

4.2.2 Phased Thoracic-Abdominal Compression-Decompression CPR With a Handheld Device

Phased thoracic-abdominal compression-decompression CPR (PTACD-CPR) combines the concepts of IAC-CPR and ACD-CPR. A handheld device alternates chest compression and abdominal decompression with chest decompression and abdominal compression. Evidence from 1 prospective randomized clinical study of adults in cardiac arrest[77] demonstrated no improvement in survival to hospital discharge with use of PTACD-CPR during out-of-hospital cardiac arrest. There is insufficient evidence to support or refute the use of PTACD-CPR for the treatment of cardiac arrest.

4.2.3 Impedance Threshold Device - Updated[ALS 579]

The impedance threshold device (ITD) is a pressure-sensitive valve that is attached to an endotracheal tube (ETT), supraglottic airway, or face mask. The ITD limits air entry into the lungs during the decompression phase of CPR, enhancing the negative intrathoracic pressure generated during chest wall recoil, thereby improving venous return to the heart and cardiac output during CPR. It does so without impeding positive-pressure ventilation or passive exhalation. The ITD is removed after return of spontaneous circulation (ROSC) is achieved. The ITD has been used alone as a circulatory adjunct as well as in conjunction with active compression-decompression CPR (ACD-CPR) devices. The ITD and ACD-CPR are thought to act synergistically to enhance venous return and improve cardiac output during CPR.[78,79] Although initially used as part of a circuit with a cuffed ETT during bag-tube ventilation, the ITD can also be used with a face mask, provided that a tight seal is maintained between the face and mask.

4.2.3.1 2015 Evidence Summary

Three randomized controlled trials (RCTs) in humans have examined the benefits of incorporating the ITD as an adjunct to conventional CPR in out-of-hospital cardiac arrest (OHCA). One small single-site RCT of 22 patients with femoral artery catheters demonstrated that a functioning ITD applied to an ETT significantly increased systolic blood pressures as compared with a sham device, although there was no difference in ROSC rates.[80] The second RCT examined the safety and survival to intensive care unit admission of a functioning versus sham ITD in 230 patients.[81] The ITD was initially placed on a face mask and was relocated to the ETT after intubation. This study found no difference in ROSC, intensive care unit admission, or 24-hour survival between the 2 groups. The third and largest RCT examined the impact of a functioning ITD versus a sham device at 10 sites in the United States and Canada as part of the Resuscitation Outcomes Consortium (ROC) Prehospital Resuscitation Impedance Valve and Early Versus Delayed Analysis (PRIMED) study.[82] Of the 8718 patients

included in this high-quality RCT, 4345 were randomized to resuscitation with a sham ITD and 4373 were assigned to resuscitation with the functioning ITD. The ROC PRIMED study permitted placement of the ITD on a face mask, supraglottic airway, or ETT. This large multicenter RCT did not show a benefit from the addition of the ITD to conventional CPR for neurologically intact survival to hospital discharge or survival to hospital discharge. There were no differences in adverse events (pulmonary edema or airway bleeding) between the 2 groups.

4.2.3.2 2015 Recommendation—New

The routine use of the ITD as an adjunct during conventional CPR is not recommended.
(Class III: No Benefit, LOE A)

This Class of Recommendation, new in 2015, indicates that high-quality evidence did not demonstrate benefit or harm associated with the ITD when used as an adjunct to conventional CPR.

4.2.4 Active Compression-Decompression CPR and Impedance Threshold Device - Updated[ALS 579]

ACD-CPR is performed by using a handheld device with a suction cup applied over the midsternum of the chest. After chest compression, the device is used to actively lift up the anterior chest during decompressions. The application of external negative suction during decompression enhances the negative intrathoracic pressure (vacuum) generated by chest recoil, thereby increasing venous return (preload) to the heart and cardiac output during the next chest compression. ACDCPR is believed to act synergistically with the ITD to enhance venous return during chest decompression and improves blood flow to vital organs during CPR. Commercially available ACD-CPR devices have a gauge meter to guide compression and decompression forces and a metronome to guide duty cycle and chest compression rate. The use of ACD-CPR in comparison with conventional CPR was last reviewed for the 2010 Guidelines. Since the 2010 Guidelines, new evidence is available regarding the use of ACD-CPR in combination with the ITD.

4.2.4.1 2015 Evidence Summary

The combination of ACD-CPR with an ITD has been studied in 4 RCTs reported in 5 publications.[79,83-86] Two of these trials evaluated ACD-CPR with the ITD in comparison with ACDCPR alone.[79,83] The first of these used femoral artery catheters to measure improved hemodynamic parameters but found no difference in ROSC, 24-hour survival, or survival to hospital discharge.[79] In a follow-up RCT of 400 patients, the ACD-CPR with a functioning ITD increased 24-hour survival, but again there was no difference in survival to hospital discharge or survival with good neurologic function as compared with the ACD-CPR with sham ITD group.[83]

The remaining 2 RCTs compared ACD-CPR with the ITD versus conventional CPR. The first was a single-center RCT in which 210 patients were randomly assigned to ACD-CPR+ITD or conventional CPR after intubation by the advanced life support team, which arrived on scene a mean of 9.5 minutes after the 9-1-1 call.[84] The chest compression and ventilation rates in both arms were 100/min and 10 to 12 breaths/min, respectively. The ROSC, 1-hour, and 24-hour rates of survival were all significantly improved in the ACDCPR+ITD group as compared with conventional CPR, but survival to hospital discharge and survival with favorable neurologic outcome were not significantly different. The second trial is the ResQ trial, which was conducted in 7 distinct geographic regions of the United States. In the ResQ trial, conventional CPR was performed with compressions at 100/min, with a compression-to-ventilation ratio of 30:2 during basic life support and ventilation rate of 10/min after intubation. In the ACD-CPR+ITD group, compressions were performed at a rate of 80/min and ventilation at a rate of 10/min. In the intervention arm, a metronome was used to guide the compression rate, a force gauge was used to guide compression depth and recoil, and timing lights on the ITD were used to guide ventilation rate. Two analyses of data from the ResQ trial have been published; the first was restricted to OHCA of presumed cardiac etiology,[85] and the second included all enrolled patients.[86] The complete trial enrolled 2738 patients (conventional CPR=1335, ACD-CPR+ITD=1403) before it was terminated early because of funding constraints.[86] Survival to hospital discharge with favorable neurologic function (modified Rankin Scale score of 3 or less) was greater in the ACD-CPR+ITD group as compared with the conventional CPR group: 7.9% versus 5.7% (odds ratio, 1.42; 95% confidence interval, 1.04–1.95), and this difference was maintained out to 1 year. For survival to hospital discharge with favorable neurologic function, this translates into a number needed to treat of 45 with very wide confidence limits (95% confidence interval, 25–333), making interpretation of the true clinical effect challenging. There was no difference in the overall incidence of adverse events, although pulmonary edema was more common with ACD-CPR+ITD as compared with conventional CPR (11.3% versus 7.9%; P=0.002). The ResQ

Trial had a number of important limitations, including lack of blinding, different CPR feedback elements between the study arms (ie, co-intervention), lack of CPR quality assessment, and early termination. Although improved neurologic function was noted with the use of the ACD-CPR+ITD combination at both hospital discharge and 1-year follow-up, additional trials are needed to confirm these findings.

4.2.4.2 2015 Recommendation—New

The existing evidence, primarily from 1 large RCT of low quality, does not support the routine use of ACD-CPR+ITD as an alternative to conventional CPR. The combination may be a reasonable alternative in settings with available equipment and properly trained personnel. (Class IIb, LOE C-LD)

4.2.5 Mechanical Chest Compression Devices:Piston Device - Updated[ALS 782]

A mechanical piston device consists of an automated compressed gas- or electric-powered plunger positioned over the sternum, which compresses the chest at a set rate. Some devices incorporate a suction cup at the end of the piston that is designed to actively decompress the chest after each compression, whereas others do not.

4.2.5.1 2015 Evidence Review

The Lund University Cardiac Arrest System (LUCAS) is a gas- (oxygen or air) or electric-powered piston device that produces a consistent chest compression rate and depth. It incorporates a suction cup on the end of the piston that attaches to the sternum and returns the sternum to the starting position when it retracts. A small pilot RCT found similar survival in patients randomly assigned to mechanical versus manual chest compressions.[87] Subsequently, 2 large RCTs, the Prehospital Randomised Assessment of a Mechanical Compression Device in Cardiac Arrest (PARAMEDIC)[88] and LUCAS in Cardiac Arrest (LINC)[89] trials, have compared the use of LUCAS against manual compressions for patients with OHCA. Together, these studies enrolled 7060 patients, and neither demonstrated a benefit for mechanical CPR over manual CPR with respect to early (4-hour) and late (1- and 6-month) survival.[88,89] The PARAMEDIC study demonstrated a negative association between mechanical chest compressions and survival with good neurologic outcome (Cerebral Performance Category 1–2) at 3 months as compared with manual compressions.

A number of other mechanical piston devices have been compared with manual chest compressions in studies of OHCA. There are no large-scale RCTs with these devices. Three small (largest sample size of 50 patients) RCTs found no differences in early survival[90-92] despite improvements in end-tidal CO2 in patients randomly assigned to mechanical piston devices in 2 of these 3 studies.[91,92] However, in neither of these studies did any patient survive to hospital discharge. Time-motion analysis of manual versus mechanical chest compressions showed that it took considerable time to deploy the mechanical piston device, prolonging the no-chest compression interval during CPR.[93]

4.2.5.2 2015 Recommendation—New

The evidence does not demonstrate a benefit with the use of mechanical piston devices for chest compressions versus manual chest compressions in patients with cardiac arrest. Manual chest compressions remain the standard of care for the treatment of cardiac arrest, but mechanical piston devices may be a reasonable alternative for use by properly trained personnel. (Class IIb, LOE B-R)

The use of mechanical piston devices may be considered in specific settings where the delivery of high-quality manual compressions may be challenging or dangerous for the provider (eg, limited rescuers available, prolonged CPR, during hypothermic cardiac arrest, in a moving ambulance, in the angiography suite, during preparation for extracorporeal CPR [ECPR]), provided that rescuers strictly limit interruptions in CPR during deployment and removal of the devices. (Class IIb, LOE C-EO)

4.2.6 Load-Distributing Band Devices - Updated[ALS 782]

The load-distributing band (LDB) is a circumferential chest compression device composed of a pneumatically or electrically actuated constricting band and backboard.

4.2.6.1 2015 Evidence Summary

While early case series[94-96] of patients treated with LDB-CPR were encouraging, an observational study exploring a number of treatments related to new guideline implementation suggested that the use of LDB-CPR was associated with lower odds of 30-day survival when compared with concurrent patients receiving only manual CPR.[97] One multicenter prospective RCT[98] comparing LDB-CPR (Autopulse device) with manual CPR for OHCA demonstrated no improvement in 4-hour survival and worse neurologic outcome when the device was compared with manual CPR. Site-specific factors[99] and experience with deployment of the device[100] may have influenced the outcomes in this study. In a high-quality multicenter RCT of 4753 OHCA patients, LDB-CPR (Autopulse device) and manual chest compressions were shown to be equivalent with respect to the outcome of survival to hospital discharge. Both approaches in this study were carefully monitored to minimize hands-off time and to optimize compression technique.[101]

4.2.6.2 2015 Recommendation—New

The evidence does not demonstrate a benefit with the use of LDB-CPR for chest compressions versus manual chest compressions in patients with cardiac arrest. Manual chest compressions remain the standard of care for the treatment of cardiac arrest, but LDB-CPR may be a reasonable alternative for use by properly trained personnel. (Class IIb, LOE B-R)

The use of LDB-CPR may be considered in specific settings where the delivery of high-quality manual compressions may be challenging or dangerous for the provider (eg, limited rescuers available, prolonged CPR, during hypothermic cardiac arrest, in a moving ambulance, in the angiography suite, during preparation for ECPR), provided that rescuers strictly limit interruptions in CPR during deployment and removal of the devices. (Class IIb, LOE C-EO)

5 Extracorporeal Techniques and Invasive Perfusion Devices - Updated

5.1 Extracorporeal CPR - Updated ALS 723

For the purpose of this Guidelines Update, the term ECPR is used to describe the initiation of cardiopulmonary bypass during the resuscitation of a patient in cardiac arrest. This involves the emergency cannulation of a large vein and artery (eg, femoral vessels) and initiation of venoarterial extracorporeal circulation and oxygenation. The goal of ECPR is to support patients between cardiac arrest and restoration of spontaneous circulation while potentially reversible conditions are addressed. ECPR is a complex process that requires a highly trained team, specialized equipment, and multidisciplinary support within the local healthcare system.

5.1.1 2015 Evidence Summary

There are no data on the use of ECPR from RCTs. Early observational studies in small numbers of witnessed in-hospital cardiac arrest (IHCA) and OHCA patients younger than 75 years with potentially reversible conditions suggested improved survival when compared with conventional CPR.[102-106] Patients receiving ECPR in these studies tended to be younger, with more witnessed arrests and bystander CPR.

The 2015 ILCOR ALS Task Force reviewed several observational studies, some of which used propensity matching. The results of the studies are mixed. One propensity-matched prospective observational study enrolling 172 IHCA patients reported greater likelihood of return of spontaneous beating in the ECPR group (compared with ROSC in the conventional CPR group) and improved survival at hospital discharge, 30-day, and 1-year follow-up with the use of ECPR. However, this study showed no difference in neurologic outcomes.[107] A retrospective observational study including 120 IHCA patients with historic control reported a modest benefit in both survival and neurologic outcome at discharge and 6-month follow-up with the use of ECPR versus

conventional CPR.[108] A propensity-matched retrospective observational study enrolling 118 IHCA patients showed no survival or neurologic benefit with ECPR at the time of hospital discharge, 30-day, or 1-year follow-up.[106] One post hoc analysis of data from a prospective, observational cohort of 162 OHCA patients, including propensity score matching, showed that ECPR was associated with a higher rate of neurologically intact survival at 3-month follow-up.[109] A prospective observational study enrolling 454 OHCA patients demonstrated improved neurologic outcomes with the use of ECPR at 1-month and 6-month follow-up after arrest.[110]

5.1.2 2015 Recommendation—New

There is insufficient evidence to recommend the routine use of ECPR for patients with cardiac arrest.

In settings where it can be rapidly implemented, ECPR may be considered for select patients for whom the suspected etiology of the cardiac arrest is potentially reversible during a limited period of mechanical cardiorespiratory support. (Class IIb, LOE C-LD)

Published series have used rigorous inclusion and exclusion criteria to select patients for ECPR. Although these inclusion criteria are highly variable, most included only patients aged 18 to 75 years, with arrest of cardiac origin, after conventional CPR for more than 10 minutes without ROSC. Such inclusion criteria should be considered in a provider's selection of potential candidates for ECPR.

6 Authorship and Disclosures

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Table 1: Part 6: Alternative Techniques and Ancillary Devices for Cardiopulmonary Resuscitation: 2015 Guidelines Update Writing Group Disclosures

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Part 6: Alternative Techniques and Ancillary Devices for Cardiopulmonary 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**
Steven C. Brooks	Queen's University	Heart and Stroke Foundation†; South Eastern Ontario Academic Medical Organization†; Canadian Institutes of Health Research†; National Institutes of Health Research†; Department of Defense, Canada†; US Military†;	None	None	None	None	None	Eastern Ontario Academic Medicine Organization†

Writing Group Member	Employment	Research Grant	Other Research Support	Speakers' Bureau/Honoraria	Expert Witness	Ownership Interest	Consultant/Advisory Board	Other
Monique L. Anderson	Duke Clinical Research Institute	None	None	None	None	None	None	None
Eric Bruder	Emergency Medicine	None	None	None	None	None	None	None
Mohamud R. Daya	Oregon Health and Science University	NIH-NHLBI†; NIH*; NIH-NINR*	None	None	None	None	Philips Health Care –Uncompens	None
Alan Gaffney	Columbia University Medical Center; University of Arizona	None	None	None	None	None	None	None
Charles W. Otto	University of Arizona College of Medicine	None	None	None	None	None	None	None
Adam J. Singer	Stony Brook University	AHA*; NY State*	None	None	None	None	None	None
Ravi R. Thiagarajan	Children's Hospital, Boston	NHLBI*	None	None	None	None	None	None
Consultant								
Andrew H. Travers	Emergency Health Services, Nova Scotia	None	None	None	None	None	None	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.

6.2 2010 Writing Team

Diana M. Cave, Chair; Raul J. Gazmuri; Charles W. Otto; Vinay M. Nadkarni; Adam Cheng; Steven C. Brooks; Mohamud Daya; Robert M. Sutton; Richard Branson; Mary Fran Hazinski

Table 2: 2010 - Guidelines Part 7: CPR Techniques and Devices: Writing Group Disclosures

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2010 Guidelines Part 7: CPR Techniques and Devices: Writing Group Disclosures

Writing Group Member	Employment	Research Grant	Other Research Support	Speakers' Bureau/Honoraria	Ownership Interest	Consultant/Advisory Board	Other
Diana M. Cave	Legacy Health System, Emanuel Hospital, Emergency Services–RN, MSN; Portland Com. College–Institute for Health Prof.-Faculty/Instructor	None	None	None	None	None	None

Writing Group Member	Employment	Research Grant	Other Research Support	Speakers' Bureau/Honoraria	Ownership Interest	Consultant/Advisory Board	Other
Raul Gazmuri	North Chicago VA Medical Center–Section Chief, Critical Care and Professor of Medicine	†Volume-Controlled Manual Ventilation during Resuscitation from Cardiac Arrest. Funded by Dessinier Corporation. Funds come to my institution (Rosalind Franklin UniversityRFU Vitamin-C Preserves Myocardial Distensibility during Resuscitation from CA. Funded by Maribor University, Slovenia. Funds come to my institution (RFU)	None	None	†Patent titled "Facilitation of Resuscitation from Cardiac Arrest by Erythropoietin" (pending)	None	None
Charles W. Otto	University of Arizona–Professor	None	None	None	None	None	None
Vinay M. Nadkarni	University of Pennsylvania/Children's Hospital of Philadelphia–A Physician, Departement of Anesthesia, Critical Care and Pediatrics	None	None	None	None	None	*Voluntary (Unpaid) member of Data Safety Monitoring Committee for Automated CPR device trial

Writing Group Member	Employment	Research Grant	Other Research Support	Speakers' Bureau/Honoraria	Ownership Interest	Consultant/Advisory Board	Other
Adam Cheng	British Columbia Children's Hospital: University Affiliated–Director, Pediatric Simulation Program	†American Heart Association RFP - educational grant. Money comes to my institution, and is distributed to our group of collaborative pediatric hospitals	None	None	None	None	None

Writing Group Member	Employment	Research Grant	Other Research Support	Speakers' Bureau/Honoraria	Ownership Interest	Consultant/Advisory Board	Other
Steven C. Brooks	University of Toronto–Clinic Scientist	†PI-1. Univ.of Toronto Faculty of Medicine New Staff Grant. 01/07/2009–01 A pilot study to explore missed opportunities for public access defibrillation in OHCA and to determine the potential impact of emergency medical dispatchers. Role: PI $10 000 unrestricted grant administered through the research institute 2. University of Toronto Connaught New Staff Matching Grant 2009–2010. 04/05/2009–0: Development of Centres of Excellence to Improve Outcomes after OHCAt: A Pilot Study. Role: PI $23 700 unrestricted grant administered through the research institute 3. Ontario Ministry of Health and Long Term Care and th					

Writing Group Member	Employment	Research Grant	Other Research Support	Speakers' Bureau/Honoraria	Ownership Interest	Consultant/Advisory Board	Other
Mohamud Daya	Oregon Health & Science University: Attending Physician–Associate Professor of Emergency Medicine	†PI Resuscitation Outcomes Consoritum - Portland Site, NHLBI, grant is awarded directly to the insitution (OHSU)	None	*Lectures at local, regional and national meetings, income is directly to me, last lectures CPR update at the Timberline EMS conference, there was no honorarium but conference paid for my lodging Stroke Update in Corvallis at Samaritan Health, Honorarium fee was 500 dollars Advanced 12 lead ECG diagnostic algoritms, Lecutre for Philips Healthcare at EMS today, honoarium for 2 lectures was 1000 dollars	*Stock held in the following health care companies; Johnson and Johnson - 250 shares Amgen - 100 shares Roche - 100 shares	*Philips Health Care - Consultant on 12 lead ECG diagnostic algorithms and resuscitation products, no reimbursement for this activity	†I am an EMS medical director for 2 fire departments and one 911 agency, this is a private contract and the money comes directly to me, this is independent of my employment at OHSU which is at an 80% FTE level, my EMS activities are 20% FTE

Writing Group Member	Employment	Research Grant	Other Research Support	Speakers' Bureau/Honoraria	Ownership Interest	Consultant/Advisory Board	Other
Robert M. Sutton	The Children's Hospital of Philadelphia–Care Attending	*Unrestricted Research Grant Support through a Center of Excellence Grant from the Laerdal Found	None	None	None	None	
Richard Branson	University of Cincinnati-Associate Professor	None	†SeQual. Sponsor of laboratory study of the use of oxygen concentrators in conjunction with mechanical ventilators for military and mass casualty scenarios. $40 000. All monies are paid to the Univ. I have no financial interest in the company and do not receive any personal income	†Cardinal - makers of ICU and home care ventialtors. I am paid directly for speaking. Newport Medical makers of ICU and home care ventilators. I am paid directly for speaking. * IKARIA - manufactures and distributes inhaled nitric oxide. I am paid directly	None	*Bayer Pharmaceuticals Treatment of ventilator associated pneumonia	*KIngs Daughters Hospital Ashalnd KY. Paid directly to me

Writing Group Member	Employment	Research Grant	Other Research Support	Speakers' Bureau/Honoraria	Ownership Interest	Consultant/Advisory Board	Other
Mary Fran Hazinski	Vanderbilt University School of Nursing—Profe American Heart Association–Senior Science Editor † Significant AHA compensation for my editing responsibilities writing and editing of the 2010 AHA Guidelines for CPR and ECC	None	None	None	None	None	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.

7 Footnotes

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

American Heart Association. Web-based Integrated Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care – Part 6: Alternative Techniques and Ancillary Devices for Cardiopulmonary Resuscitation. ECCguidelines.heart.org

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