Part 7: CPR Techniques and Devices

2010 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations

Michael Shuster, Co-Chair*; Swee Han Lim, Co-Chair*; Charles D. Deakin; Monica E. Kleinman; Rudolph W. Koster; Laurie J. Morrison; Jerry P. Nolan; Michael R. Sayre; on behalf of the CPR Techniques and Devices Collaborators

Note From the Writing Group: Throughout this article, the reader will notice combinations of superscripted letters and numbers (eg, “Open-Chest CPRALS-CPR&A-004A, ALS-CPR&A-004B”). These callouts are hyperlinked to evidence-based worksheets, which were used in the development of this article. An appendix of worksheets, applicable to this article, is located at the end of the text. The worksheets are available in PDF format and are open access.

The success of any cardiopulmonary resuscitation (CPR) technique or device depends on the education and training of the rescuers as well as on resources (including personnel). In the hands of some groups, novel techniques and adjuncts may produce better short- or long-term outcomes than standard CPR. However, a device or technique that provides good-quality CPR when used by a highly trained team or in a test setting may show poor quality and create frequent interruptions in CPR when used in an uncontrolled clinical setting.1

While no circulatory adjunct is currently recommended instead of manual CPR for routine use, some circulatory adjuncts are being routinely used in both out-of-hospital and in-hospital resuscitation. If a circulatory adjunct is used, rescuers should be well trained and a program of continuous surveillance should be in place to ensure that use of the adjunct does not adversely affect survival. The following CPR techniques and devices were reviewed during the 2010 International Consensus Conference. It should be noted that interposed abdominal compression (IAC) has not been studied in humans since 1994 and active compression-decompression (ACD) has not been studied in humans since 2003. Therefore these techniques have not been evaluated against the international resuscitation guideline changes of 2000 and 2005 for IAC and 2005 for ACD.

Interposed Abdominal Compression (IAC)-CPR

Consensus on Science
Two randomized controlled trials in in-hospital cardiac arrests, showed improved return of spontaneous circulation (ROSC) and survival to hospital discharge when IAC-CPR was compared with standard CPR (LOE I²; LOE 2³). However, there were no differences in neurologically intact survival.

One randomized controlled trial in out-of-hospital cardiac arrest was unable to show any consistent benefits when IAC-CPR was compared with standard CPR (LOE 2).4

Evidence from LOE 3⁵,⁶ and LOE 5⁷ in-hospital studies suggested better or neutral⁸,⁹ hemodynamics with IAC-CPR compared with standard CPR.

Treatment Recommendation
There is insufficient evidence to support or refute the use of IAC-CPR.

Active Compression-Decompression (ACD)-CPR

Consensus on Science
Five randomized controlled trials (LOE 1)¹⁰–¹⁴ and 3 controlled trials (LOE 2)¹⁵–¹⁷ failed to show a difference in ROSC or survival with use of ACD-CPR compared with standard CPR.

Six studies (LOE 2)¹⁸–²³ demonstrated improved ROSC or survival to hospital discharge although there were no statistically significant differences in neurologically intact survival.

A meta-analysis¹⁴ of 2 trials (826 patients) comparing ACD-CPR with standard CPR after in-hospital cardiac arrest (IHCA) did not detect a significant increase in rates of immediate survival or survival to hospital discharge.

Treatment Recommendation
There is insufficient evidence to support or refute the use of ACD-CPR.

Open-Chest CPR

Consensus on Science
There are no published randomized controlled trials and very limited data in humans comparing open-chest CPR to standard CPR in cardiac arrest. One retrospective clinical trial (LOE 3)²⁴ demonstrated that ROSC was improved by open-chest CPR in out-of-hospital cardiac arrest. One case series in
victims of out-of-hospital cardiac arrest who had failed standard CPR (LOE 4)\textsuperscript{55} reported ROSC in 13 of 33 highly selected patients; 2 survived to hospital discharge.

Multiple animal studies (LOE 5)\textsuperscript{26–44} using a variety of endpoints demonstrated benefit with open-chest CPR.

**Treatment Recommendation**
There is insufficient evidence to support or refute the routine use of open-chest CPR in cardiac arrest.

**Load Distributing Band (LDB)–CPR**

**ALS/BLS-CPR&A-086A, ALS/BLS-CPR&A-086B**

**Consensus on Science**
One multicenter RCT in over 1000 adults documented no improvement in 4-hour survival and significantly worse neurologic outcome when LDB-CPR administered by EMS providers was compared with traditional CPR for out-of-hospital cardiac arrest of presumed cardiac origin (LOE 1).\textsuperscript{45} However, a posthoc analysis of this study revealed significant heterogeneity among study sites (LOE 1).\textsuperscript{46}

In one LOE 3 study,\textsuperscript{47} the use of LDB-CPR was associated with lower odds of 30-day survival (OR 0.4). However, when a smaller (77-patient) subgroup of LDB-CPR-treated patients was analyzed against concurrent controls, an increased rate of ROSC was noted.\textsuperscript{47}

Other nonrandomized human series (LOE 3) have reported increased rates of sustained ROSC\textsuperscript{48,49} and increased survival to discharge\textsuperscript{50} following out-of-hospital cardiac arrest and improved hemodynamics following failed resuscitation from in-hospital cardiac arrest (LOE 4).\textsuperscript{51} In a prospective before-and-after study (LOE 3),\textsuperscript{51} the mean no-flow ratio with manual CPR was 0.28 in the first 5 minutes of CPR compared with 0.40 with LDB-CPR. However between 5 and 10 minutes, no-flow time was 0.34 with manual CPR and 0.21 with LDB-CPR.

Evidence from both clinical (LOE 1)\textsuperscript{45,46} and simulation (LOE 5)\textsuperscript{52} studies suggested that site-specific factors may influence resuscitation quality and device efficacy.

A case report documented successful performance of a computed tomography (CT) scan while LDB-CPR was used (LOE 4).\textsuperscript{53}

**Treatment Recommendation**
There are insufficient data to support or refute the routine use of LDB-CPR instead of manual CPR. It may be reasonable to consider LDB to maintain continuous chest compression while undergoing CT scan or similar diagnostic studies, when provision of manual CPR would be difficult.

**Mechanical (Piston) CPR**

**ALS/BLS-CPR&A-083A, ALS/BLS-CPR&A-083B**

**Consensus on Science**
When a piston-CPR device was compared with manual CPR, one RCT documented no improvement in ROSC or survival among adults in cardiac arrest (LOE 1).\textsuperscript{54}

Supportive data from 1 prospective, randomized crossover-design study (LOE 1)\textsuperscript{55} and 1 paired-cohort study (LOE 2)\textsuperscript{56} documented that the use of a piston-CPR device improved hemodynamics during CPR in adult cardiac arrest victims.

One prospective pseudorandomized trial documented improvement in hemodynamic variables during CPR in adult cardiac arrest victims but no improvement in ROSC or survival (LOE 2).\textsuperscript{57}

Data from 1 prospective cohort study comparing the use of a piston-CPR device with manual CPR documented that the use of a piston-CPR device increased interruption in CPR because time was required to set up and remove the device from patients during transportation in adult OHCA (LOE 2).\textsuperscript{58}

**Treatment Recommendation**
There is insufficient evidence to support or refute the use of piston-CPR instead of manual CPR for adult victims of cardiac arrest.

**Lund University Cardiac Arrest System (LUCAS) CPR**

**ALS/BLS-CPR&A-085A, ALS/BLS-CPR&A-085B**

**Consensus on Science**
There are no RCTs evaluating the LUCAS device in human cardiac arrest.

One study using concurrent controls in witnessed out-of-hospital cardiac arrest was unable to show any benefit (ROSC, survival to hospital, or survival to hospital discharge) with the use of the LUCAS device over the use of standard CPR (LOE 2).\textsuperscript{59}

One postmortem study showed similar injuries with LUCAS-CPR and standard CPR (LOE 2).\textsuperscript{60}

Six case series involving approximately 200 patients have reported variable success in use of the LUCAS device when implemented after an unsuccessful period of manual CPR (LOE 4).\textsuperscript{61–66}

Three adult human case reports (LOE 4),\textsuperscript{62,67,68} 3 adult human case series (LOE 4),\textsuperscript{63,66,69} and 1 animal study (LOE 5)\textsuperscript{68} reported that the use of a mechanical chest-compression device in cardiac arrest during percutaneous coronary intervention (PCI) maintained circulation and enabled the procedure to be completed. A small number of patients in the case series survived.

Two case reports demonstrated that a CT scan could be performed during CPR with the LUCAS device (LOE 4).\textsuperscript{53}

**Treatment Recommendation**
There are insufficient data to support or refute the use of LUCAS-CPR instead of manual CPR. It may be reasonable to consider LUCAS-CPR to maintain continuous chest compression while undergoing CT scan or similar diagnostic studies, when provision of manual CPR would be difficult.

**Impedance Threshold Device (ITD)**

**ALS/BLS-CPR&A-081A, ALS/BLS-CPR&A-081B**

**Consensus on Science**
One meta-analysis that pooled the data from both conventional CPR and ACD-CPR RCTs demonstrated improved ROSC and short-term survival but no significant improvement in either survival to discharge or neurologically intact survival to discharge associated with the use of an ITD in the management of adult OHCA patients (LOE 1).\textsuperscript{70}

One RCT suggested that the use of an ITD in combination with ACD-CPR improved 24-hour survival and survival to intensive care unit (ICU) admission in adult out-of-hospital cardiac arrest patients, compared with ACD-CPR and a sham ITD (LOE 1).\textsuperscript{71} This contrasts with another RCT that com-
pared ITD plus ACD-CPR with ACD-CPR plus a sham ITD, which did not show significant improvement in ROSC or 24-hour survival with use of the ITD (LOE 1).72

One RCT reported that the use of an ITD in combination with standard CPR did not significantly improve ROSC, 24-hour survival, or survival to ICU admission in adult out-of-hospital cardiac arrest, compared with CPR and a sham ITD (LOE 1).73

One RCT comparing ACD-CPR plus ITD with CPR in adult out-of-hospital cardiac arrest showed improved ROSC and 24-hour survival rates associated with ACD-CPR plus ITD, but no significant improvement in rates of hospital discharge or intact neurologic survival to hospital discharge (LOE 1).74

One prospective cohort study (with historical control) of CPR plus ITD versus CPR without ITD in out-of-hospital cardiac arrest reported improved survival to emergency department (ED) admission for patients presenting in any rhythm (LOE 3).75

Three cohort studies comparing CPR using the 2005 AHA Guidelines for CPR and ECC plus ITD, with historic controls of CPR using the 2000 AHA Guidelines for CPR and ECC, demonstrated improved survival to hospital discharge in out-of-hospital cardiac arrest (LOE 3).76–78 It was not possible to determine the relative contribution of the ITD to the improved outcome.

In a porcine model of cardiac arrest, 8 studies demonstrated improved hemodynamic variables during CPR with use of the ITD (LOE 5).79–86 An additional 3 animal studies (LOE 5)87–89 showed no difference in survival or in any hemodynamic variable, and 2 animal studies (LOE 5)88,90 reported evidence of decreased ROSC, 20-minute survival, and arterial oxygen saturation associated with the use of an ITD.

**Treatment Recommendation**

There are insufficient data to support or refute the use of the ITD.

**Acknowledgments**

We thank the following individuals (the CPR Techniques and Devices Collaborators) for their collaborations on the worksheets contained in this section: Syed Sameer Ali; David G. Beiser; Pierre Carli; Suzanne R. Davies; Michael Holzer; Taku Iwami; Mark S. Link; Jim McKendry; Paul M. Middleton; Peter T. Morley; Chika Nishiyama; Giuseppe Ristagno; Sten Rubertsson; and Kjetil Sunde.

**Disclosures**

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.
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Appendix

CoSTR Part 7: Worksheet Appendix

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**Key Words:** arrhythmia ■ cardiac arrest ■ cardiopulmonary resuscitation ■ emergency department ■ resuscitation
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Circulation. 2010;122:S338-S344
doi: 10.1161/CIRCULATIONAHA.110.971036
Circulation is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
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Print ISSN: 0009-7322. Online ISSN: 1524-4539

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