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 12; LOE 2). 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 356 and LOE 57 in-hospital studies suggested better or neutral89 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)$^{25}$ reported ROSC in 13 of 33 highly selected patients; 2 survived to hospital discharge.

Multiple animal studies (LOE 5)$^{26–44}$ 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)$^{45}$. However, a posthoc analysis of this study revealed significant heterogeneity among study sites (LOE 1)$^{46}$. In one LOE 3 study,$^{47}$ 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.$^{47}$

Other nonrandomized human series (LOE 3) have reported increased rates of sustained ROSC$^{48,49}$ and increased survival to discharge$^{50}$ following out-of-hospital cardiac arrest and improved hemodynamics following failed resuscitation from in-hospital cardiac arrest (LOE 4)$^{51}$. In a prospective before-and-after study (LOE 3)$^{51}$, 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)$^{45,46}$ and simulation (LOE 5)$^{52}$ 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)$^{53}$.

**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.

**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)$^{54}$. 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)$^{55}$. 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**

**CoSTR Part 7: Writing Group Disclosures**

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<th>Writing Group Member</th>
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*Modest.
†Significant.
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<td>*I am receiving money from Jolife AB, Lund, Sweden as a consult dealing with their device LUCAS-mechanical chest compressions. I am also a PI for the multi-center LINC trial which is a study of out-of-hospital CA victims allocated to either standard ACLS or ACLS including mechanical chest compressions</td>
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<td>*Advisory board for Covidean regarding VAP</td>
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Appendix

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Part 7: CPR Techniques and Devices: 2010 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations
Michael Shuster, Swee Han Lim, Charles D. Deakin, Monica E. Kleinman, Rudolph W. Koster, Laurie J. Morrison, Jerry P. Nolan and Michael R. Sayre

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