

Part 6: Defibrillation

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

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Note From the Writing Group: Throughout this article, the reader will notice combinations of superscripted letters and numbers (eg, “CPR Before Defibrillation^{BLS-024A, BLS-024B}”). 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 2010 Defibrillation Task Force considered many questions related to defibrillation. In general, the 2010 International Consensus on Science With Treatment Recommendations statement contains no major differences or dramatic changes from the 2005 International Consensus statement. The questions have been grouped into the following categories: (1) cardiopulmonary resuscitation (CPR) before defibrillation, (2) electrode-patient interface, (3) waveforms, energy levels, and strategies (4) special circumstances, and (5) defibrillation-related topics.

Science and treatment recommendations dealing with the infant or child requiring defibrillation can be found in Part 10: Pediatric Basic and Advanced Life Support. The only treatment recommendations that differ for adult and pediatric patients are defibrillation dose and automated external defibrillator (AED) use.

There are several knowledge gaps created by the lack of high-quality, large clinical studies. These include the minimal acceptable first-shock success rate; the characteristics of the optimal biphasic waveform; the optimal energy levels for specific waveforms; and the best shock strategy (fixed versus escalating).

Integration of CPR and Defibrillation

Whether a period of CPR should be performed before defibrillation in ventricular fibrillation (VF), especially after a long response time, has recently been the subject of intense debate. The theoretical rationale for CPR before shock delivery is to improve coronary perfusion and thereby the chances of achieving sustained return of spontaneous circulation (ROSC).

CPR Before Defibrillation^{BLS-024A, BLS-024B}

In adults and children with cardiac arrest due to VF (out-of-hospital or in-hospital) does the use of CPR before defibril-

lation, as opposed to standard care (according to treatment algorithm), improve outcomes (eg, ROSC, survival)?

Consensus on Science

In 2 randomized controlled trials (LOE 1)^{1,2}, a period of 1½ to 3 minutes of CPR by emergency medical services (EMS) personnel before defibrillation did not improve ROSC or survival to hospital discharge in patients with out-of-hospital VF or pulseless ventricular tachycardia (VT), regardless of EMS response interval. One before-and-after study (LOE 3)³ and another study (LOE 4)⁴ failed to demonstrate significant improvements in ROSC or survival to hospital discharge when a strategy of CPR before defibrillation (CPR first) was compared to a shock-first strategy. In the Hayakawa study, the CPR-first group showed a higher rate of favorable neurologic outcome 30 days and 1 year after cardiac arrest.³

One randomized controlled trial (LOE 1)⁵ and 1 clinical trial with historic controls (LOE 3)⁶ comparing CPR-first versus shock-first also found no overall difference in outcomes. However, in both studies, improvements in ROSC, survival to hospital discharge, neurologic outcome, and 1-year survival were observed in a subgroup of patients who received CPR first where the EMS response interval was >4 to 5 minutes.

Treatment Recommendation

There is inconsistent evidence to support or refute delay in defibrillation to provide a period of CPR (90 seconds to 3 minutes) for patients in non EMS witnessed VF/pulseless VT cardiac arrest.

Electrode-Patient Interface

Studies on defibrillation for cardiac arrest and on cardioversion for atrial fibrillation (AF) are both included here. While few studies compared differences in outcome, many studies compared secondary end points such as effect on transthoracic impedance (TTI). In ventricular arrhythmias, however, there is no direct evidence that TTI affects shock success.

Self-Adhesive Defibrillation Pads Compared With Paddles^{ALS-E-037A}

In adult cardiac arrest (out-of-hospital [OHCA], in-hospital [IHCA]) does the use of self-adhesive defibrillation pads,

The American Heart Association requests that this document be cited as follows: Jacobs I, Sunde K, Deakin CD, Hazinski MF, Kerber RE, Koster RW, Morrison LJ, Nolan JP, Sayre MR; on behalf of Defibrillation Chapter Collaborators. Part 6: defibrillation: 2010 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations. *Circulation*. 2010;122(suppl 2):S325–S337.

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(*Circulation*. 2010;122[suppl 2]:S325–S337.)

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Circulation is available at <http://circ.ahajournals.org>

DOI: 10.1161/CIRCULATIONAHA.110.971010

compared with paddles, improve outcomes (eg, successful defibrillation, ROSC, survival)?

Consensus on Science

Since 2005 there have been no new studies comparing self-adhesive defibrillation pads with paddles in cardiac arrest. Evidence from one small, good-quality controlled study (LOE 3)⁷ in 1987 showed that self-adhesive pads were associated with a significantly improved rate of ROSC and hospital admission compared with hand-held paddles. Several studies have shown the practical benefits of pads over paddles for routine monitoring and defibrillation.^{8–12}

One prospective study (LOE 3)¹³ found lower TTI when paddles applied at an optimal force of 8 kg were compared with pads. In a cohort study in patients with atrial fibrillation (LOE 2)¹⁴ the use of hand-held paddles placed in the anterior-posterior position increased the success rate of monophasic cardioversion compared with similarly placed self-adhesive electrodes for monophasic defibrillation. The overall cardioversion success rate for biphasic defibrillators was high (>95%) in all groups. In the majority of other studies, self-adhesive electrodes were associated with similarly high cardioversion success rates.

Treatment Recommendation

For both defibrillation and AF cardioversion, when using biphasic defibrillators, self-adhesive defibrillation pads are safe and effective and are an acceptable alternative to standard defibrillation paddles. In AF cardioversion using monophasic defibrillators, hand-held paddles are preferable.

Placement of Paddles/Pads^{ALS-E-030A}

In adult cardiac arrest (OHCA, IHCA) does the use of any specific paddle/pad size/orientation and position, compared with standard resuscitation (or other specific paddle/pad size/orientation and position), improve outcomes (eg, successful defibrillation, ROSC, survival)?

Consensus on Science

There are no studies in patients with VF/pulseless VT directly comparing the effects of various positions of paddle/pad placement on defibrillation success and ROSC. Most studies evaluate cardioversion (eg, AF) or secondary end points (eg, TTI). Eleven studies (LOE 5)^{15–25} found all 4 positions (anterior-apex, anterior-posterior, anterior–left infrascapular, anterior–right infrascapular) to be equally effective in defibrillation (for VF/pulseless VT) or elective AF cardioversion success. Four studies support the anterior-posterior position (LOE 5),^{26–30} 1 study supports the anterior-lateral position (LOE 5),³¹ and 1 study supports the anterior-apex position (LOE 5).³²

Five studies (LOE 5)^{16,21–24} found no effect of electrode position on TTI. One study showed that paddles/pads should be placed under the breast tissue (LOE 5)³³ and 2 studies showed that hirsute males should be shaved before the application of pads (LOE 5).^{34,35} Of the 36 studies reviewed, only 4 examined biphasic waveforms (LOE 5)^{18,25,29,36} that have gained widespread use.

Treatment Recommendation

It is reasonable to place paddles/pads on the exposed chest in an anterior-lateral position. Acceptable alternative positions are anterior-posterior (for paddles/pads) and apex-posterior (for

pads). In large-breasted individuals it is reasonable to place the left electrode paddle/pad lateral to or underneath the left breast, avoiding breast tissue. Consideration should be given to the rapid removal of excessive chest hair before the application of paddles/pads but emphasis must be on minimizing delay in shock delivery.

Size of Paddles/Pads^{ALS-E-030A}

In adult cardiac arrest (OHCA, IHCA) does the use of any specific paddle/pad size/orientation and position, compared with standard resuscitation (or other specific paddle/pad size/orientation and position), improve outcomes (eg, successful defibrillation, ROSC, survival)?

Consensus on Science

No new clinical study on this topic has been published since 2005. One study demonstrated that TTI decreased and shock success increased with increasing pad size (from 8 to 12 cm) (LOE 3).³⁷ Ten other studies showed that larger paddle/pad sizes (8- to 12-cm diameter) lowered TTI and that maximum paddle/pad size was limited by the chest wall size and anatomy (LOE 3;³⁸ LOE 5^{23,36,39–45}). No data related to survival outcome was included in these studies.

Treatment Recommendation

There is insufficient evidence to recommend a specific electrode size for optimal external defibrillation in adults. However, it is reasonable to use a paddle/pad size >8 cm.

Composition of Conductive Material^{ALS-E-036}

In adult cardiac arrest (OHCA, IHCA) does the use of any specific composition of conductive material, compared with standard conductive material, improve TTI?

Consensus on Science

Fourteen studies showed that the composition of the conductive material (eg, saline, hypertonic sodium chloride [NaCl] solution, or silver-silver chloride) may alter TTI by more than 20% (LOE 2^{39,46,47}; LOE 3³⁷; LOE 4⁴⁸; LOE 5^{34,49–56}). Five studies (LOE 3^{57,58}; LOE 5^{59–61}) showed that TTI was not affected by electrode composition. The end point for all of these studies was TTI, and no studies involved outcomes following cardiac arrest.

Treatment Recommendation

The composition of the conductive material of defibrillation electrodes influences TTI. In terms of cardiac arrest outcomes, there is insufficient evidence to recommend a specific composition of the defibrillation electrode conductive material.

Waveforms, Energy Levels, and Strategies^{ALS-E-033B}

All new defibrillators currently deliver shocks using biphasic waveforms. Although it has not been demonstrated conclusively in randomized clinical studies that biphasic defibrillators save more lives than monophasic defibrillators, biphasic defibrillators achieve higher first-shock success rates. Shock success is usually defined as termination of VF 5 seconds after the shock.

In adult cardiac arrest due to VF or pulseless VT (OHCA, IHCA), does the use of any specific defibrillation strategy, compared with standard management (or other specific defibrillation strategy), improve outcomes (eg, termination of VF 5 seconds after the shock)?

Biphasic Compared With Monophasic Defibrillation Waveform Consensus on Science

In 3 randomized trials (LOE 1)^{62–64} and 4 other human studies (LOE 3)^{65–68} biphasic waveforms had higher shock-success rates compared with monophasic defibrillation. One randomized study comparing transthoracic incremental monophasic with biphasic defibrillation for out-of-hospital pulseless VT/VF cardiac arrest failed to demonstrate any significant differences in any outcome (LOE 1).⁶⁹ A single-cohort study (LOE 3)⁷⁰ using the 2000 International Guidelines⁷¹ demonstrated better hospital discharge and neurological survival with biphasic than with monophasic waveforms. However, there were confounding factors in that the intervals between the first and second shocks (of 3-stacked shocks) were shorter with the biphasic defibrillators.

There is no clinical evidence for superiority of any specific biphasic waveform over another.

Treatment Recommendation

Biphasic waveforms are more effective in terminating VF when compared with monophasic waveforms. There is insufficient evidence to recommend any specific biphasic waveform. In the absence of biphasic defibrillators, monophasic defibrillators are acceptable.

Multiphasic Compared With Biphasic Defibrillation Waveform Consensus on Science

There are no human studies to support the use of multiphasic waveforms over biphasic waveforms for defibrillation. Animal data suggests that multiphasic waveforms may defibrillate at lower energies and induce less postshock myocardial dysfunction.^{72,73} These results are limited because in all studies duration of VF was very short (approximately 30 seconds) and results have not been validated in human studies.

Treatment Recommendation

Currently, multiphasic defibrillators are not commercially available.

Waveforms, Energy Levels, and Myocardial Damage

Several different biphasic waveforms are used in commercially available defibrillators, but no human studies have directly compared these waveforms or compared them at different energy levels related to defibrillation success or survival.

For the different biphasic waveforms, studies of different size and quality have been performed and are presented separately. For all waveforms, insufficient evidence exists to make clear recommendations.

Consensus on Science

Biphasic Truncated Exponential (BTE) Waveform. Evidence from 1 well-conducted randomized trial (LOE 1)⁷⁴ and 1 other human study (LOE 2)⁷⁵ employing BTE waveforms suggested that higher energy levels are associated with higher shock-success rates. In the randomized trial, the first-shock success rate was similar with 150 J and 200 J.⁷⁴

Pulsed Biphasic Waveform. In one study using pulsed biphasic waveforms at 130 J the first-shock success rate was 90% (LOE 4).⁷⁶

Rectilinear Biphasic Waveform. When defibrillation success was defined as ROSC (this differs from the definition in other studies), one study using a rectilinear biphasic waveform showed that an organized rhythm was restored by the first shock (120 J) in 23% of cases (LOE 1).⁶² Success rate for the termination of VF at 5 seconds was not published for this waveform.

Monophasic Waveform (Damped Sinusoid or Truncated Exponential). Evidence from 3 studies of monophasic defibrillation suggested equivalent outcomes with lower and higher starting energies (LOE 1⁷⁷; LOE 2^{78,79}).

Myocardial Damage Associated With Higher-Energy Level Shocks. Several animal studies have suggested the potential for myocardial damage with higher-energy shocks using BTE or monophasic waveforms (LOE 5).^{36,80–81} In a recent prolonged cardiac arrest pig study, however, biphasic 360 J shocks did not appear to cause more cardiac damage than biphasic 150 J shocks (LOE 5).⁸² Human studies involving BTE waveforms^{74,83} with energy levels up to 360 J have not shown harm as indicated by biomarker levels, ECG findings, and ejection fractions.

Treatment Recommendation

It is reasonable to start at a selected energy level of 150 J to 200 J for a BTE waveform for defibrillation of pulseless VT/VF cardiac arrest. There is insufficient evidence to determine the initial energy levels for any other biphasic waveform. Although evidence is limited, because of the lower total shock success for monophasic defibrillation, initial and subsequent shocks using this waveform should be at 360 J.

One-Shock Compared With 3-Stacked Shock Protocols

Consensus on Science

One study showed no survival benefit from a protocol that included a single-shock protocol compared to a 3-shock protocol (LOE 1).⁸⁴ Evidence from 3 pre-post design studies suggested significant survival benefit with a single-shock defibrillation protocol compared with 3-stacked shock protocols (LOE 3).^{85–87} However, these studies included confounders related to pre-post design and the multiple interventions that were included as part of the defibrillation protocol. Another pre-post study, with fewer confounding factors, showed a significantly lower hands-off ratio (ie, percentage of total CPR time when no compressions were provided) with the 1-shock protocol but no statistical difference in survival (LOE 3).⁸⁸

One observational study of fixed-dose biphasic defibrillation suggested higher defibrillation success with 3 shocks (LOE 4).⁸⁹ The same study also suggested that chest compressions immediately following a shock did not result in recurrence of VF. In contrast another study showed earlier recurrence of VF when chest compressions were resumed immediately after the shock compared with delayed resumption of compressions (LOE 1).⁹⁰ There was no significant difference in total incidence of recurrent VF or outcome. A single study demonstrated that early termination of recurrent VF was associated with increased ROSC, but quality of CPR was poor and few patients achieved ROSC (LOE 4).⁹¹ Another study showed decreased survival when defibrillation for recurrent VF was, for a variety of reasons, delayed (LOE 4).⁹²

Treatment Recommendation

When defibrillation is required, a single shock should be provided with immediate resumption of chest compressions after the shock. Chest compressions should not be delayed for rhythm reanalysis or pulse check immediately after a shock. CPR should not be interrupted until rhythm reanalysis is undertaken.

Fixed Versus Escalating Defibrillation Energy Protocol^{ALS-E-032B}

In adult cardiac arrest (OHCA, IHCA) does the use of an escalating defibrillation energy protocol, compared with a fixed-energy protocol, improve outcomes (eg, ROSC)?

Consensus on Science

One randomized trial (LOE 1)⁷⁴ of 150-J fixed versus 200-J to 300-J to 360-J shocks and 1 LOE 2 study⁷⁵ of 150-J fixed versus 100-J to 150-J to 200-J shocks supported the use of an escalating-energy biphasic defibrillation protocol compared with a fixed-dose defibrillation protocol. In one study (escalating 200-J to 200-J to 360-J shocks), the success rate of defibrillation for recurrent VF declined with the number of recurrences (LOE 4).⁹³ However, these studies were not designed to demonstrate an improvement in the rate of ROSC or survival to hospital discharge. One study of fixed-dose biphasic defibrillation suggested that defibrillation success improved with 3 shocks (LOE 4).⁸⁹ All of these studies were done with the 3-shock protocol (before the change in Guidelines 2005).

Treatment Recommendation

For second and subsequent biphasic shocks the same initial energy level is acceptable. It is reasonable to increase the energy level when possible.

Shock Using Manual Versus Semi-Automatic Mode^{ALS-E-034B}

In adult cardiac arrest (OHCA, IHCA) does the use of an AED or a multifunctional defibrillator in automatic mode, compared with standard resuscitation (using manual defibrillation), improve outcomes (eg, successful defibrillation, ROSC, survival)?

Consensus on Science

Modern defibrillators can be operated in both manual and semiautomatic (AED-similar) modes. However, few studies compare these two options. One randomized controlled study showed no significant difference in survival-to-hospital-discharge rate but significant reduction in time to first shock in the AED group versus the manual group (1.1 versus 2.0 minutes) (LOE 1).⁹⁴ One good concurrent controlled OHCA study in 36 rural communities showed no improvements in ROSC, survival, or neurologic outcome but significantly shorter times to first shock and higher VF conversion rates when paramedics used AEDs in semiautomatic mode compared with manual mode (LOE 2).⁹⁵ One retrospective study demonstrated no improvement in survival to hospital discharge for adult IHCA when comparing AED with manual defibrillators (LOE 4).⁹⁶ In patients with initial asystole or pulseless electric activity (PEA), AEDs were associated with a significantly lower survival (15%) compared with manual defibrillators (23%, $P=0.04$).⁹⁶

In a study of 3 different EMS systems and 1 in-hospital center, manual mode of defibrillation was associated with a lower total hands-off ratio (ie, percentage of total CPR time when no compressions were provided) than AED mode (LOE 3).⁹⁷ However, more shocks were delivered inappropriately by rescuers using manual defibrillators (26% manual versus 6% AEDs). A randomized manikin study simulating cardiac arrest showed a lower hands-off ratio, mainly due to a shorter preshock pause, when trained paramedics used the defibrillator in manual mode compared with semiautomatic mode (LOE 5).⁹⁸ More inappropriate shocks (12% versus 0) were delivered in manual mode. All episodes of VF were detected and shocked appropriately.

A shorter preshock pause and lower total hands-off ratio increased vital organ perfusion and the probability of ROSC (LOE 5).^{99–101}

Treatment Recommendation

No significant survival differences have been demonstrated between defibrillation in semiautomatic and manual modes during out-of-hospital or in-hospital resuscitation; however, the semiautomatic mode is preferred because it is easier to use and may deliver fewer inappropriate shocks.

Trained personnel may deliver defibrillation in manual mode. Use of the manual mode enables chest compressions to be continued during charging, thereby minimizing the preshock pause. When using the defibrillator in manual mode, frequent team training and ECG recognition skills are essential.

The defibrillation mode that results in the best outcome will be influenced by the system of care and by provider skills, training, and ECG recognition.

Cardioversion Strategy in Atrial Fibrillation^{ALS-E-038}

In adult patients in a shockable nonarrest rhythm requiring cardioversion (in- or out-of-hospital) does any specific cardioversion strategy, compared with standard management (or other specific cardioversion strategy), improve outcomes (eg, termination of rhythm)?

Consensus on Science

Twenty-two studies have compared specific cardioversion strategies (eg, monophasic versus biphasic defibrillators and different energy levels) administered by cardiologists in the hospital setting to patients with atrial fibrillation (both acute and chronic) (LOE 1^{14,17,26,27,31,102–115}; LOE 2^{116,117}). Most of these studies documented that biphasic shocks were more effective than monophasic shocks for cardioversion.

Studies with varying strategies (fixed and escalating) and energy levels all resulted in high cardioversion rates for a variety of biphasic waveforms, with no clear evidence of superiority. For monophasic defibrillation, higher initial energy levels (360 J) were associated with higher cardioversion rates and less total energy used than energy levels escalating from lower to higher. Body weight may affect cardioversion success, and one study suggested that initial shock should be 200 J for patients <90 kg and 360 J for patients >90 kg (LOE 1).¹¹⁸ In general, increased total energy use was associated with more dermal injury and postprocedural pain (LOE 1).^{103,112,119}

Treatment Recommendation

Biphasic defibrillators are preferred for cardioversion of atrial fibrillation. There is no evidence to recommend a specific waveform, energy level, or strategy (fixed versus escalating) when using biphasic defibrillators. For monophasic defibrillators, a high initial energy (360 J) seems preferable.

Special Circumstances

Some special circumstances, such as whether pacing is ever indicated during cardiac arrest or how to respond in cardiac arrest if the patient has a pacemaker or an internal defibrillator, are presented and discussed in this section.

Pacing (eg, Transcutaneous [TC], Transvenous [TV], Needle, and Fist)^{ALS-E-031}

In adult cardiac arrest (OHCA, IHCA) does the use of pacing (eg, TC, TV, and needle), compared with standard resuscitation (or no pacing), improve outcomes (eg, ROSC, survival)?

Consensus on Science

Four studies addressed the efficacy of pacing in cardiac arrest (LOE 2^{120–122}; LOE 3¹²³). These studies found no benefit from routine pacing in cardiac arrest patients. Use of pacing (eg, TC, TV, and needle) in cardiac arrest (in- or out-of-hospital) did not improve ROSC or survival. There was no apparent benefit related to the time at which pacing was initiated (early or delayed in established asystole), location of arrest (out-of-hospital or in-hospital), or primary cardiac rhythm (asystole or PEA). Five case series (LOE 4),^{124–128} a review with 2 additional case reports,¹²⁹ and a moderate-sized case series (LOE 4)¹³⁰ support percussion pacing in p-wave asystolic cardiac arrest/complete heart block or hemodynamically unstable patients with bradycardia. In these reports, sinus rhythm with a pulse was restored using different pacing techniques.

Treatment Recommendation

Electric pacing is not effective as routine treatment in patients with asystolic cardiac arrest. Percussion pacing is not recommended in cardiac arrest in general. However, fist pacing may be considered in hemodynamically unstable bradyarrhythmias until an electric pacemaker (TC or TV) is available. The use of epicardial wires to pace the myocardium following cardiac surgery is effective and is discussed elsewhere.

Implantable Cardioverter Defibrillator (ICD) or Pacemaker^{ALS-E-039B}

In adult patients with an ICD or pacemaker who are in a shockable rhythm requiring defibrillation/cardioversion (in- or out-of-hospital) does any unique or modified defibrillation/cardioversion strategy, compared with standard management, improve outcomes (eg, termination of rhythm, ROSC)?

Consensus on Science

Two case series reported pacemaker or ICD malfunction after external defibrillation when the pads were placed in close proximity to the device generator (LOE 4).^{131,132} One small study on atrial cardioversion demonstrated that positioning the pads on the chest at least 8 cm from the device generator did not produce significant damage to pacing sensing and capturing (LOE 4).¹³¹

One case report suggested that pacemaker spikes generated by devices programmed to unipolar pacing may confuse AED software and emergency personnel and may prevent the detection of VF (LOE 4).¹³³

Treatment Recommendation

In patients with an ICD or a permanent pacemaker, the placement of paddles/pads should not delay defibrillation. When treating an adult with a permanent pacemaker or an ICD, the defibrillator paddle/pad should be placed on the chest wall ideally at least 8 cm from the generator position.

The anterior-posterior and anterior-lateral paddle/pad placements on the chest are acceptable in patients with a permanent pacemaker or ICD.

Defibrillation-Related Topics**Predicting Success of Defibrillation and Outcome (VF Waveform Analysis)**^{ALS-D&P-015B}

VF waveform analysis has been shown to correlate with myocardial perfusion/coronary perfusion pressure. In theory waveform analysis could be a tool for predicting outcome of defibrillation and therefore indicate the optimal time for shock delivery.

In adult cardiac arrest (OHCA, IHCA) does the use of a technique for prediction of the likelihood of success of defibrillation (analysis of VF, etc), compared with standard resuscitation (without such prediction), improve outcomes (eg, termination of rhythm, ROSC)?

Consensus on Science

Retrospective analysis of the VF waveform in multiple clinical (LOE 1^{134,135}; LOE 4^{136–154}; LOE 5^{155,156}) and animal studies (LOE 5)^{147,157–170} and theoretical models suggested that it is possible to predict the success of defibrillation from the fibrillation waveform with varying reliability. One animal study was neutral (LOE 5).¹⁷¹ No human studies have specifically evaluated whether treatment altered by predicting success of defibrillation can improve successful defibrillation, ROSC, or survival from cardiac arrest. Multiple waveform parameters have been examined without consensus on the most important parameters to predict outcome.

Treatment Recommendation

There is insufficient evidence to support routine use of VF waveform analysis to guide defibrillation management in adult cardiac arrest in- or out-of-hospital.

Defibrillation in the Immediate Vicinity of Supplementary Oxygen^{ALS-E-035A, ALS-E-035B}

In adults and children in cardiac arrest (OHCA, IHCA) requiring defibrillation, does the presence of supplementary oxygen in the immediate vicinity, compared with no supplementary oxygen, increase the risk of fire with defibrillation attempts?

Consensus on Science

Four case reports involving adults (LOE 4)^{172–175} and 1 case report involving a neonate (LOE 4)¹⁷⁶ described fires caused by sparks generated during defibrillation attempts when paddles were used in the vicinity of high-flow (>10 L/min) oxygen. There are no case reports of fires caused by sparking when shocks were delivered using adhesive pads. In 2 manikin studies the oxygen concentration in the zone of defibrillation was not increased when ventilation devices (bag-valve device, self-inflating bag, and Hamilton Viola ventilator) were left attached to a tracheal tube or when the oxygen source was vented at least 1 meter behind the patient's mouth (LOE 5).^{177,178} One study described higher oxygen concentrations and longer washout periods when oxygen was administered in confined spaces without adequate ventilation (LOE 5).¹⁷⁹

Treatment Recommendation

Rescuers should take precautions to minimize sparking (by paying attention to pad/paddle placement, contact, etc) during attempted defibrillation. Rescuers should try to ensure that defibrillation is not attempted in an oxygen-enriched atmosphere (eg, when high-flow oxygen is directed across the chest).

Acknowledgments

We thank the following individuals (the Defibrillation Chapter Collaborators) for their collaborations on the worksheets contained in this section: Mark Angelos; Michael Baubin; M. Fernanda Bellolio; Paul A. Berlin; Richard N. Bradley; Steven M. Bradley; Saul Drajer; Trygve Eftestøl; Chokoh Genka; Erik P. Hess; Ian Jacobs; Richard Kerber; Rudolph W. Koster; Toshihiko Mayumi; Saman Nazarian; Jerry Nolan; Mark Peele; Claudia Ranniger; Giuseppe Ristagno; Comilla Sasson; and Shijie Sun.

Disclosures

CoSTR Part 6: Writing Group Disclosures

Writing Group Member	Employment	Research Grant	Other Research Support	Speakers' Bureau/Honoraria	Ownership Interest	Consultant/Advisory Board	Other
Ian Jacobs	Univ of Western Australia; Emergency Med. Teaching and Research—Professor; AHA-Evidence Eval. Expert	†a) National Health and Medical Research Council b) The Department of Health—Western Australia c) The National Heart Foundation of Australia	†Funds to the Discipline of Emergency Medicine—University of Western Australia from the Ambulance Service—Western Australia and Laerdal (Australia) to maintain the Cardiac Arrest Registry for Western Australia. Our role is to independently maintain, analyze and report outcomes of cardiac arrest in Western Australia. I oversee the operation of the registry and reporting of outcomes. These funds are not used to provide any direct or indirect salary or other financial support	None	None	None	None
Kjetil Sunde	Oslo University Hospital Ullevål	None	None	None	None	None	None
Charles D. Deakin	Southampton University Hospital NHS Trust—Doctor	None	None	None	None	None	None
Mary Fran Hazinski	Vanderbilt University School of Nursing—Professor; American Heart Association ECC Programs—Consultant, Senior Science Editor; *I receive significant compensation from the AHA for my work as a Senior Science Editor. Compensation is to ensure that I have the time to edit the Consensus on Science with Treatment Recommendations and the AHA Guidelines for CPR and ECC	None	None	None	None	None	None
Richard E. Kerber	University of Iowa Hospital: Hospital—teaching—Physician	None	None	*Occasional lectures at Cardiology Grand Rounds at other institutions	*General Electric stock	*One-time consultant visit to Philips Defibrillator Division	*Occasional expert witness in malpractice litigation. These do not at present involve cardiac drugs or devices *DSMB member for "CIRC" clinical trial sponsored by Zoll medical
Rudolph W. Koster	Academic Medical Center: Academic hospital—clinical staff cardiologist	†Medtronic Physio-Control 2005–2009: salary support (€80,000,-annually) for the maintenance of infrastructure of data collection and analysis of OOH cardiac arrest in the area of North-Holland. Money was donated to the hospital. I had no personal financial benefit from this support. Electrodes used by first responders during an embedded randomized trial (conducted under the umbrella of the infrastructural support) were replaced free of charge	†Medtronic Physio-Control 2005–2009: salary support (€80,000,-annually) for the maintenance of infrastructure of data collection and analysis of OOH cardiac arrest in the area of North-Holland. Money was donated to the hospital. I had no personal financial benefit from this support. Electrodes used by first responders during an embedded randomized trial (conducted under the umbrella of the infrastructural support) were replaced free of charge	None	None	None	None

(Continued)

CoSTR Part 6: Writing Group Disclosures, *Continued*

Writing Group Member	Employment	Research Grant	Other Research Support	Speakers' Bureau/Honoraria	Ownership Interest	Consultant/Advisory Board	Other
Laurie J. Morrison	St. Michaels Hospital; Clinician	*Laerdal Foundation Centre Grant—infrastructure support no salary support	None	None	None	None	None
Jerry P. Nolan	Royal United Hospital NHS Trust—Consultant in Anesthesia and Critical care Medicine	None	None	None	None	None	None
Michael R. Sayre	The Ohio State University—Associate Professor	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.

CoSTR Part 6: Worksheet Collaborator Disclosures

Worksheet Collaborator	Employment	Research Grant	Other Research Support	Speakers' Bureau/Honoraria	Ownership Interest	Consultant/Advisory Board	Other
Mark Angelos	The Ohio State University—Professor	None	None	None	None	None	None
Michael Baubin	General Hospital Innsbruck—senior anesthetist	†€99 000 from the Austrian National Bank for 2 years for the project “Satisfaction in the Emergency Medicine” for the institution for personal costs of other involved people. *Personally—I receive no money from these grants	None	*Last year for an invited lecture on “Quality Management in Emergency Medicine”	None	None	None
M. Fernanda Belloio	Mayo Clinic—Senior Research Fellow	None	None	None	None	None	None
Paul A. Berlin	Gig Harbor Fire & Medic One—Medical Division Chief	None	None	*Honoraria received for teaching at Physio-Control learning center at EMS Today Conference 2009 on topics not directly related to Physio-Control products	None	None	None
Richard N. Bradley	The University of Texas Health Science Center at Houston—Associate Professor of Emergency Medicine; Texas Air National Guard—Residency Trained Flight Surgeon	None	None	None	None	None	*Volunteer member of the American Red Cross Council on First Aid, Safety and Preparedness, serve as the CPR sub-council chairman; also a volunteer board member of the Greater Houston Chapter of the Am.Red Cross
Steven M. Bradley	University of Washington—Cardiology Fellow	None	None	None	None	None	None
Saul Drajer	Clinica de la Esperanza: A 130 bed gen. hospital located in Buenos Aires, Argentina and affiliated to the Maimonides Univ. School of Medicine, with CPR teaching capabilities—Gen. Director	None	None	None	None	None	None

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CoSTR Part 6: Worksheet Collaborator Disclosures, *Continued*

Worksheet Collaborator	Employment	Research Grant	Other Research Support	Speakers' Bureau/Honoraria	Ownership Interest	Consultant/ Advisory Board	Other
Trygve Eftestøl	Univ of Stavanger Acad. Institute, Prof. I Tech	†I have been collaborator in a project receiving grant corresponding to the funding of one PostDoc position for 14.5 months from the Laerdal Foundation. I am collaborator in a project receiving grant corresponding to the funding of one PostDoc position for 30 months from the Norwegian Air Abulance Foundation	None	None	None	None	None
Chokoh Genka	Saiseika Kawaguchi General Hospital—Chief of Cardiology	None	None	None	None	None	None
Erik P. Hess	Mayo Clinic: Department of Emergency Medicine—Senior Associate Consultant	None	None	None	None	None	None
Toshihiko Mayumi	Nagoya University Hospital: Doctor—Assistant professor	None	None	None	None	None	None
Samam Nazarian	Johns Hopkins University—Assistant Professor of Medicine	None	None	None	None	None	None
Mark Peele	Department of Defense: Clinical cardiac electrophysiologist—Cardiologist/Electrophysiologist	None	None	None	None	None	None
Claudia Ranniger	George Washington University Medical Faculty Associates—staff emergency physician; George Washington University: Direct teaching activities in the GWU Medical Center Simulation Center—Medical Director, Simulation Center	†PI for AHA-sponsored grant to investigate 1) training modalities for ACLS; 2) ACLS skills retention; 3) ACLS checklist utilization. Total grant amount \$300 000 to GWU. Grant concluded June 2009	None	None	None	None	None
Giuseppe Ristagno	Weil Institute of Critical Care Medicine—Assistant Professor	None	None	None	None	None	None
Comilla Sasson	University of Michigan—Clinical Lecturer Department of Emergency Medicine	†Robert Wood Johnson Clinical Scholars Program—3 year research fellowship	None	None	None	None	None
Shijie Sun	Weil Institute of Critical Care Medicine—Professor	None	None	None	None	None	None

This table represents the relationships of worksheet collaborators that may be perceived as actual or reasonably perceived conflicts of interest as reported on the Disclosure Questionnaire, which all worksheet collaborators 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

CoSTR Part 6: Worksheet Appendix

Task Force	WS ID	PICO Title	Short Title	Authors	URL
ALS	ALS-D&P-015B	In adult cardiac arrest (prehospital [OHCA], in-hospital [IHCA]) (P), does the use of a technique for prediction of the likelihood of success of defibrillation (analysis of VF, etc) (I) compared with standard resuscitation (without such prediction) (C), improve outcomes (eg. successful defibrillation, ROSC, survival) (O).	Waveform analysis for predicting successful defibrillation	Mark Angelos, Trygve Eftestøl	http://circ.ahajournals.org/site/C2010/ALS-D-P-015B.pdf
ALS	ALS-E-030A	In adult cardiac arrest (prehospital [OHCA], in-hospital [IHCA]) (P), does the use of any specific paddle/pad size/orientation and position (I) compared with standard resuscitation or other specific paddle/pad size/orientation and position) (C), improve outcomes (eg. successful defibrillation, ROSC, survival) (O).	Paddle size and placement for defibrillation	Michael Baubin, Comilla Sasson	http://circ.ahajournals.org/site/C2010/ALS-E-030A.pdf

(Continued)

CoSTR Part 6: Worksheet Appendix, *Continued*

Task Force	WS ID	PICO Title	Short Title	Authors	URL
ALS	ALS-E-030A	In adult cardiac arrest (prehospital [OHCA], in-hospital [IHCA]) (P), does the use of any specific paddle/pad size/orientation and position (I) compared with standard resuscitation or other specific paddle/pad size/orientation and position) (C), improve outcomes (eg. successful defibrillation, ROSC, survival) (O).	Paddle size and placement for defibrillation	Michael Baubin, Comilla Sasson	http://circ.ahajournals.org/site/C2010/ALS-E-030A.pdf
ALS	ALS-E-031	In adult cardiac arrest (prehospital [OHCA], in-hospital [IHCA]) (P), does the use of pacing (eg. TV, TC, needle) (I) compared with standard resuscitation (or no pacing) (C), improve outcomes (eg. ROSC, survival) (O).	Pacing for cardiac arrest	M. Fernanda Bellolio, Paul A. Berlin, Erik P. Hess	http://circ.ahajournals.org/site/C2010/ALS-E-031.pdf
ALS	ALS-E-032B	In adult cardiac arrest (prehospital [OHCA], in-hospital [IHCA]) (P), does the use of an escalating defibrillation energy protocol (I) when compared with a fixed energy protocol (C) increase outcome (eg. return of spontaneous circulation) (O)?	Escalating vs fixed defibrillation energy	Steven M. Bradley	http://circ.ahajournals.org/site/C2010/ALS-E-032B.pdf
ALS	ALS-E-033B	In adult cardiac arrest due to VF or pulseless VT (prehospital [OHCA], in-hospital [IHCA]) (P), does the use of any specific defibrillation strategy (I) compared with standard management (or other defibrillation strategy) (C), improve outcomes (eg. termination of rhythm, ROSC, survival) (O)?	Defibrillation strategies for VF or VT	Steven M. Bradley	http://circ.ahajournals.org/site/C2010/ALS-E-033B.pdf
ALS	ALS-E-034B	In adult cardiac arrest (prehospital [OHCA], in-hospital [IHCA]) (P), does the use of an AED or a multifunctional defibrillator in automatic mode (I) compared with standard resuscitation (using manual defibrillation) (C), improve outcomes (eg. successful defibrillation, ROSC, survival) (O)?	AED vs manual defibrillator	Giuseppe Ristagno	http://circ.ahajournals.org/site/C2010/ALS-E-034B.pdf
ALS	ALS-E-035A	In adult and pediatric patients in cardiac arrest (prehospital [OHCA], in-hospital [IHCA]) (P) requiring defibrillation, does the presence of supplementary oxygen in the immediate vicinity (I) compared with no supplementary oxygen (C), increase the risk of fire with defibrillation attempts (O).	Risk of fire with oxygen and defibrillation	Jerry Nolan	http://circ.ahajournals.org/site/C2010/ALS-E-035A.pdf
ALS	ALS-E-035B	In adult and pediatric patients in cardiac arrest (prehospital [OHCA], in-hospital [IHCA]) (P) requiring defibrillation, does the presence of supplementary oxygen in the immediate vicinity (I) compared with no supplementary oxygen (C), increase the risk of fire with defibrillation attempts (O).	Risk of fire with oxygen and defibrillation	Claudia Ranniger	http://circ.ahajournals.org/site/C2010/ALS-E-035B.pdf
ALS	ALS-E-036	In adult cardiac arrest (prehospital [OHCA], in-hospital [IHCA]) (P), does the use of any specific composition of conductive material (I) compared with standard conductive material (C), improve transthoracic impedance (O).	Conductive materials for defibrillation	Saul Drajer, Richard Kerber	http://circ.ahajournals.org/site/C2010/ALS-E-036.pdf
ALS	ALS-E-037A	In adult cardiac arrest (prehospital [OHCA], in-hospital [IHCA]) (P), does the use of self-adhesive defibrillation pads (I) compared with paddles (C), improve outcomes (eg. successful defibrillation, ROSC, survival) (O)?	Adhesive pads vs paddles for defibrillation	Chokoh Genka, Toshihiko Mayumi	http://circ.ahajournals.org/site/C2010/ALS-E-037A.pdf
ALS	ALS-E-038	In adult patients in a shockable non-arrest rhythm requiring cardioversion (prehospital or in-hospital) (P), does the any specific cardioversion strategy (I) compared with standard management (or other cardioversion strategy) (C), improve outcomes (eg. termination of rhythm) (O).	Cardioversion strategies	Richard N. Bradley, Shijie Sun	http://circ.ahajournals.org/site/C2010/ALS-E-038.pdf
ALS	ALS-E-039B	In adult patients with an ICD or pacemaker and who are in a shockable rhythm requiring defibrillation/cardioversion (prehospital or in-hospital) (P), does the any unique or modified cardioversion/defibrillation strategy (I) compared with standard management (C), improve outcomes (eg. termination of rhythm, ROSC) (O).	Cardioversion strategies with ICD or pacemakers	Saman Nazarian, Mark Peele	http://circ.ahajournals.org/site/C2010/ALS-E-039B.pdf
BLS	BLS-024A	In adult and pediatric patients with cardiac arrest due to VF (prehospital or in-hospital) (P), does the use of CPR before defibrillation (I) as opposed to standard care (according to treatment algorithm) (C), improve outcome (O) (eg. ROSC, survival)?	CPR prior to defibrillation	Ian Jacobs	http://circ.ahajournals.org/site/C2010/BLS-024A.pdf
BLS	BLS-024B	In adult and pediatric patients with cardiac arrest due to VF (prehospital or in-hospital) (P), does the use of CPR before defibrillation (I) as opposed to standard care (according to treatment algorithm) (C), improve outcome (O) (eg. ROSC, survival)?	CPR prior to defibrillation	Rudolph W. Koster	http://circ.ahajournals.org/site/C2010/BLS-024B.pdf

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KEY WORDS: arrhythmia ■ cardiac arrest ■ cardiopulmonary resuscitation ■ defibrillation ■ emergency department

Part 6: Defibrillation: 2010 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations

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Circulation. 2010;122:S325-S337

doi: 10.1161/CIRCULATIONAHA.110.971010

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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