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Part 1: Executive summary
2010 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations☆

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Toward International Consensus on Science

The International Liaison Committee on Resuscitation (ILCOR) was founded on November 22, 1992, and currently includes representatives from the American Heart Association (AHA), the European Resuscitation Council (ERC), the Heart and Stroke Foundation of Canada (HSFC), the Australian and New Zealand Committee on Resuscitation (ANZCOR), Resuscitation Council of Southern Africa (RCSA), the InterAmerican Heart Foundation (IAHF), and the Resuscitation Council of Asia (RCA). Its mission is to identify and review international science and knowledge relevant to cardiopulmonary resuscitation (CPR) and emergency cardiovascular care (ECC) and when there is consensus to offer treatment recommendations. Emergency cardiovascular care includes all responses necessary to treat sudden life-threatening events affecting the cardiovascular and respiratory systems, with a particular focus on sudden cardiac arrest.

In 1999, the AHA hosted the first ILCOR conference to evaluate resuscitation science and develop common resuscitation guidelines. The conference recommendations were published in the *International Guidelines 2000 for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care*.[1] Since 2000, researchers from the ILCOR member councils have evaluated resuscitation science in 5-year cycles. The conclusions and recommendations of the 2005 International Consensus Conference on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care With Treatment Recommendations were published at the end of 2005.[2,3] The most recent International Consensus Conference was held in Dallas in February 2010, and this publication contains the consensus science statements and treatment recommendations developed with input from the invited participants.

The goal of every resuscitation organisation and resuscitation expert is to prevent premature cardiovascular death. When cardiac arrest or life-threatening emergencies occur, prompt and skillful response can make the difference between life and death and between intact survival and debilitation. This document summarises the 2010 evidence evaluation of published science about the recognition and response to sudden life-threatening events, particularly sudden cardiac arrest and peri-arrest events in victims of all ages. The broad range and number of topics reviewed necessitated succinctness in the consensus science statements and brevity in treatment recommendations. This supplement is not a comprehensive review of every aspect of resuscitation medicine; not all topics reviewed in 2005 were reviewed in 2010. This executive summary highlights the evidence evaluation and treatment recommendations of the 2010 evidence evaluation process. More detailed information is available in other parts of this publication.

Evidence evaluation process

To begin the current evidence evaluation process, ILCOR representatives established 6 task forces: basic life support (BLS); advanced life support (ALS); acute coronary syndromes (ACS); paediatric life support; neonatal life support; and education, implementation, and teams (EIT). Separate writing groups were formed to coordinate evidence evaluation for defibrillation and mechan-

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Table 1
Levels of Evidence.

C2010 Levels of Evidence for Studies of Therapeutic Interventions
LOE 1: Randomized controlled trials (RCTs) (or meta-analyses of RCTs)
LOE 2: Studies using concurrent controls without true randomization (eg, "pseudo"-randomized)
LOE 3: Studies using retrospective controls
LOE 4: Studies without a control group (eg, case series)
LOE 5: Studies not directly related to the specific patient/population (eg, different patient/population, animal models, mechanical models, etc)
C2010 Levels of Evidence for Prognostic Studies
LOE P1: Inception (prospective) cohort studies (or meta-analyses of inception cohort studies), or validation of Clinical Decision Rule (CDR)
LOE P2: Follow-up of untreated control groups in RCTs (or meta-analyses of follow-up studies), or derivation of CDR, or validated on split-sample only
LOE P3: Retrospective cohort studies
LOE P4: Case series
LOE P5: Studies not directly related to the specific patient/population (eg, different patient/population, animal models, mechanical models, etc)
C2010 Levels of Evidence for Diagnostic Studies
LOE D1: Validating cohort studies (or meta-analyses of validating cohort studies) or validation of Clinical Decision Rule (CDR)
LOE D2: Exploratory cohort study (or meta-analyses of follow-up studies), or derivation of CDR, or a CDR validated on a split-sample only
LOE D3: Diagnostic case-control study
LOE D4: Study of diagnostic yield (no reference standard)
LOE D5: Studies not directly related to the specific patient/population (eg, different patient/population, animal models, mechanical models, etc)

ical devices because these overlapped with both BLS and ALS. Each task force identified topics requiring evidence evaluation and invited international experts to review them. To ensure a consistent and thorough approach, a worksheet template was created with step-by-step directions to help the experts document their literature reviews, evaluate studies, determine levels of evidence (Table 1), and develop treatment recommendations (see Part 3: Evidence Evaluation Process).[4] When possible, 2 expert reviewers were invited to perform independent evaluations for each topic. The worksheet authors submitted their search strategies to 1 of 3 worksheet review experts. The lead evidence evaluation expert also reviewed all worksheets and assisted the worksheet authors in ensuring consistency and quality in the evidence evaluation. This process is described in detail in Part 3.[4] In conjunction with the International First Aid Science Advisory Board, the AHA established an additional task force to review evidence on first aid. This topic is summarised in Part 13. The evidence review followed the same process but was not part of the formal ILCOR review.

The evidence evaluation process from 2007 to 2009 initially involved 509 worksheet authors with 569 worksheets. Some of the worksheets were merged while in other cases there was no new evidence and the worksheets/topics were deleted. The 2010 International Consensus Conference in February, 2010 involved 313 experts from 30 countries. A final total of 277 specific resuscitation questions, each in standard PICO (Population, Intervention, Comparison, Outcome) format, were considered by 356 worksheet authors who reviewed thousands of relevant, peer-reviewed publications. Many of these worksheets were presented and discussed at monthly or semimonthly task force international web conferences (i.e., "webinars" that involved conference calls with simultaneous internet conferencing). Beginning in May 2009 the evidence review and summary portions of the evidence evaluation worksheets, with worksheet author conflict of interest (COI) statements, were posted on the ILCOR Web site (www.ilcor.org). Journal advertisements and emails invited public comment. Persons who submitted comments were required to indicate their potential conflicts of interest. Public comments and potential conflicts of interest were sent to the appropriate ILCOR task force chair and worksheet author for consideration.

To provide the widest possible dissemination of the science reviews performed for the 2010 International Consensus Conference, the worksheets prepared for the conference are linked from this document and can be accessed by clicking on the superscript worksheet numbers (each begins with a W) located adjacent to headings.

During the 2010 Consensus Conference, wireless Internet access was available to all conference participants to facilitate real-time verification of the literature. Expert reviewers presented summaries of their evidence evaluation in plenary and concurrent sessions. Presenters and participants then debated the evidence, conclusions, and draft summary statements. The ILCOR task forces met daily during the conference to discuss and debate the experts' recommendations and develop interim consensus science statements. Each science statement summarised the experts' interpretation of all relevant data on a specific topic, and included consensus draft treatment recommendations. The wording of science statements and treatment recommendations was revised after further review by ILCOR member organisations and the editorial board. This format ensures that the final document represents a truly international consensus process.

At the time of submission this document represented the state-of-the-art science of resuscitation medicine. With the permission of the relevant journal editors, several papers were circulated among task force members if they had been accepted for publication in peer-reviewed journals but had not yet been published. These peer-reviewed and accepted manuscripts were included in the consensus statements.

This manuscript was ultimately approved by all ILCOR member organisations and an international editorial board (listed on the title page of this supplement). Reviewers solicited by the editor of *Circulation* and the AHA Science Advisory and Coordinating Committee performed parallel peer reviews of this document before it was accepted for publication. This document is being published online simultaneously by *Circulation* and *Resuscitation*, although the version in the latter publication does not include the section on first aid.

Management of potential conflicts of interest

In order to ensure the evidence evaluation process was free from commercial bias, extensive conflict of interest management principles were instituted immediately following the completion of the 2005 Consensus on CPR and ECC Science and Treatment Recommendations (CoSTR), concurrent with the start of the 2010 CoSTR process. All of the participants were governed by the COI management principles regardless of their role in the CoSTR process. COI disclosure was required from all participants and was updated annually or when changes occurred. Commercial relationships were considered at every stage of the evidence evaluation process

and, depending on the nature of the relationship and their role in the evidence evaluation process, participants were restricted from some activities (i.e., leading, voting, deciding, writing, discussing) that directly or indirectly related to that commercial interest. While the focus of the process was the evaluation of the scientific evidence, attention was given to potential COI throughout the CoSTR process.[5–7] This policy is described in detail in Part 4: "Management of Potential Conflicts of Interest."[8]

Applying science to improve survival

From consensus on science to guidelines

This document presents international consensus statements that summarise the science of resuscitation and, wherever possible, treatment recommendations. ILCOR member organisations will subsequently publish resuscitation guidelines that are consistent with the science in this consensus document, but the organisations will also take into account geographic, economic, and system differences in practice; availability of medical devices and drugs (e.g., not all devices and drugs reviewed in this publication are available and approved for use in all countries); and ease or difficulty of training. All ILCOR member organisations are committed to minimising international differences in resuscitation practice and optimising the effectiveness of resuscitation practice, instructional methods, teaching aids, training networks and outcomes (see Part 2: ILCOR Collaboration).

The recommendations of the 2010 International Consensus Conference confirm the safety and effectiveness of current approaches, acknowledge other approaches as ineffective, and introduce new treatments resulting from evidence-based evaluation. *New and revised treatment recommendations do not imply that clinical care that involves the use of previously published guidelines is either unsafe or ineffective*. Implications for education and retention were also considered when developing the final treatment recommendations.

Ischaemic heart disease is the leading cause of death in the world.[9,10] In addition, many newly born infants die worldwide as the result of respiratory distress immediately after birth. However, most out-of-hospital victims die without receiving the interventions described in this publication.

The actions linking the adult victim of sudden cardiac arrest with survival are called the adult Chain of Survival. The links in the Chain of Survival used by many resuscitation councils include prevention of the arrest, early recognition of the emergency and activation of the emergency medical services (EMS) system, early and high-quality CPR, early defibrillation, rapid ALS, and postresuscitation care. The links in the infant and child Chain of Survival are prevention of conditions leading to cardiopulmonary arrest, early and high-quality CPR, early activation of the EMS system, and early ALS.

The most important determinant of survival from sudden cardiac arrest is the presence of a trained lay rescuer who is ready, willing, and able to act. Although some ALS techniques improve survival,[11,12] these improvements are usually less significant than the increase in survival rates that can result from higher rates of lay rescuer (bystander) CPR and establishment of automated external defibrillation programs in the community.[13–17] Thus, our greatest challenges remain the education of the lay rescuer and understanding and overcoming the barriers that prevent even trained rescuers from performing high-quality CPR. We must increase the effectiveness and efficiency of instruction, improve skills retention, and reduce barriers to action for both basic and ALS providers. Similarly, the placement and use of automated external defibrillators (AEDs) in the community should be encouraged to enable defibrillation within the first minutes after a ventricular fibrillation (VF) sudden cardiac arrest.

The Universal Algorithm

Several of the new treatment recommendations cited in this document are included in the updated ILCOR Universal Cardiac Arrest Algorithm (Fig. 1). This algorithm is intended to apply to attempted resuscitation of infant, child, and adult victims of cardiac arrest (excluding newly borns). Every effort has been made to keep this algorithm simple yet make it applicable to treatment of cardiac arrest victims of all ages and in most circumstances. Modification will be required in some situations, and these exceptions are highlighted elsewhere in this document. Each resuscitation organisation has based its guidelines on this ILCOR algorithm, although there will be regional modifications.

Rescuers begin CPR if the adult victim is unresponsive with absent or abnormal breathing, such as an occasional gasp. A single compression–ventilation ratio of 30:2 is used for the lone lay rescuer of an infant, child, or adult victim (excluding newly borns). This single ratio is designed to simplify teaching, promote skills retention, increase the number of compressions given, and decrease interruptions in compressions. The most significant adult BLS change in this document is a recommendation for a CAB (compressions, airway, breathing) sequence instead of an ABC (airway, breathing, compressions) sequence to minimise delay to initiation of compressions and resuscitation. In other words, rescuers of adult victims should begin resuscitation with compressions rather than opening the airway and delivery of breaths.

Once a defibrillator is attached, if a shockable rhythm is confirmed, a single shock is delivered. Irrespective of the resultant rhythm, CPR starting with chest compressions should resume immediately after each shock to minimise the "no-flow" time (i.e., time during which compressions are not delivered, for example, during rhythm analysis). ALS interventions are outlined in a box at the center of the algorithm. Once an advanced airway (tracheal tube or supraglottic airway) has been inserted, rescuers should provide continuous chest compressions (without pauses for ventilations) and ventilations at a regular rate (avoiding hyperventilation).

The 2005 International Consensus on Science emphasised the importance of minimal interruption of chest compressions because 2005 evidence documented the frequency of interruptions in chest compressions during both in-hospital and out-of-hospital CPR and the adverse effects of such interruptions in attaining resumption of spontaneous circulation (ROSC).[18–20] In 2010, experts agree that rescuers should be taught to adhere to all four metrics of CPR: adequate rate, adequate depth, allowing full chest recoil after each compression and minimising pauses (e.g., hands off time) in compressions.

Most significant developments in resuscitation from 2005 to 2010

Although resuscitation practices are usually studied as single interventions, they are actually performed as a large sequence of actions, each with its own timing and quality of performance. It may be difficult or impossible to assess the contribution of any one action (energy level for defibrillation, airway maneuver, drug) on the most important outcomes, such as neurologically intact survival to discharge. In fact, it is likely that it is the combination of actions, each performed correctly, in time and in order, that results in optimal survival and function. A few studies give insight into this necessary shift from studying of changes in individual actions (*point improvements*) to studying the effects of changing the entire sequence of actions (*flow improvement*).[21,22]

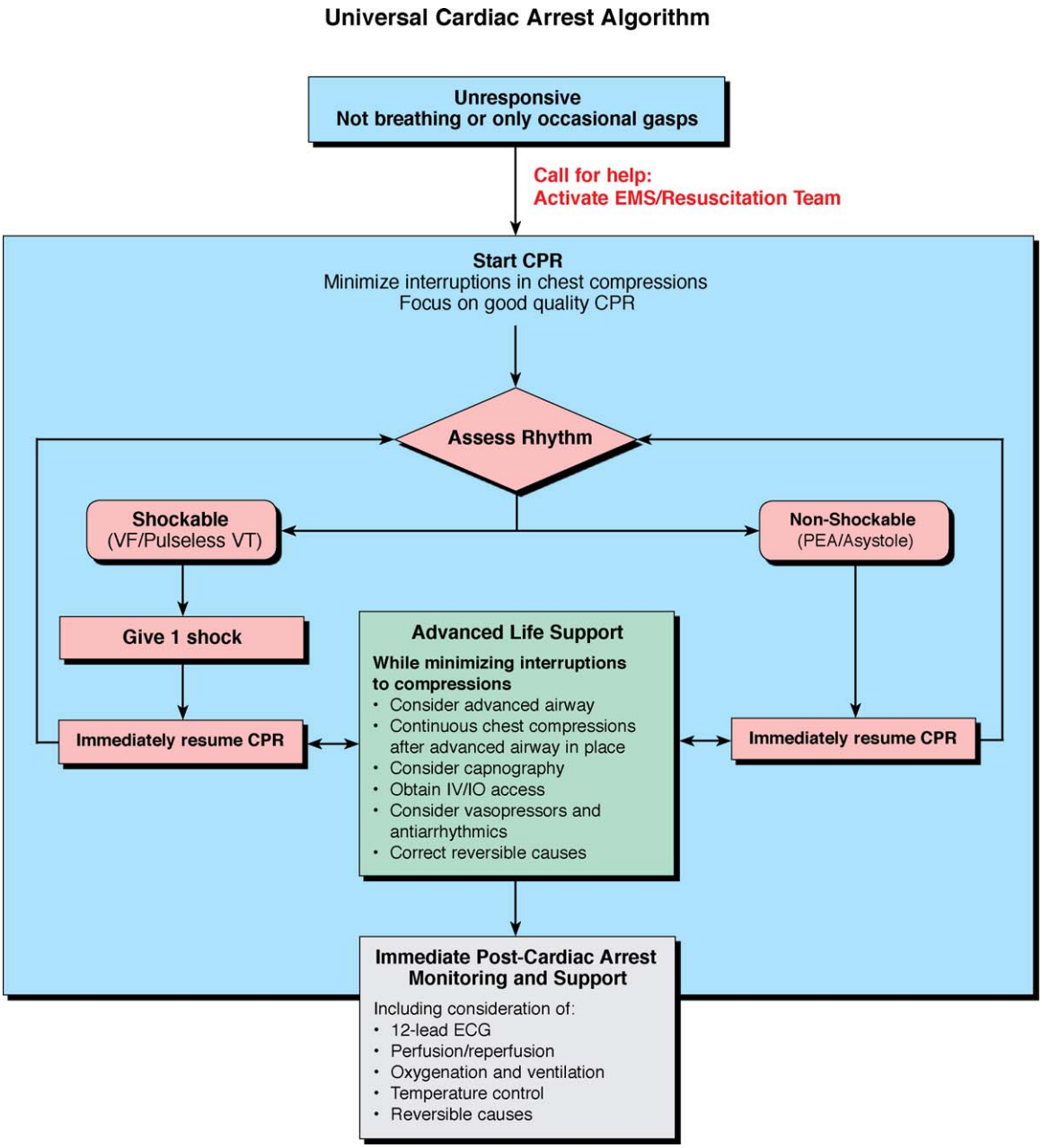

Fig. 1. The Universal Algorithm.

The compression–ventilation ratio was one of the most controversial topics of the 2005 International Consensus Conference. The experts began the 2005 conference acknowledging that rates of survival from cardiac arrest to hospital discharge were low, averaging ≤6% internationally,[23,24] and that survival rates had not increased substantially in recent years. That observation led to the 2005 change to a universal compression–ventilation ratio for all lone rescuers of victims of all ages and to an emphasis on the importance of CPR quality throughout the 2005 Consensus on CPR and ECC Science With Treatment Recommendations (CoSTR) document and subsequent ILCOR member council guidelines.[25]

Resuscitation outcomes vary considerably among regions.[26,27] In recent studies the outcome from cardiac arrest, particularly from shockable rhythms, is improved.[28–33] Moreover, there is an association between implementation of new resuscitation guidelines and improved outcome.[31,33] However, there is also evidence that new guidelines can take from 1.5 to 4 years to implement.[34,35]

There have been many developments in resuscitation science since 2005 and these are highlighted below.

Factors affecting lay rescuer CPR performance

During the past 5 years, there has been an effort to simplify CPR recommendations and emphasise the importance of high-quality CPR. Large observational studies from investigators in member countries of the RCA, the newest member of ILCOR,[36–39] and other studies[40,41] have provided significant data about the effects of bystander CPR.

CPR quality

Strategies to reduce the interval between stopping chest compressions and delivery of a shock (the preshock pause) will improve the chances of shock success.[42,43] These data are driving major

changes in training of resuscitation teams. Data downloaded from CPR-sensing and feedback-enabled defibrillators can be used to debrief resuscitation teams and improve CPR quality.[44]

In-hospital CPR registries

The National Registry of CPR (NRCPR) and other registries are providing valuable information about the epidemiology and outcomes of in-hospital resuscitation in adults and children.[45–52]

Insufficient evidence on devices and ALS drugs

Many devices remain under investigation, and at the time of the 2010 Consensus Conference there was insufficient evidence to recommend for or against the use of any mechanical devices. There are still no data showing that any drugs improve long-term outcome after cardiac arrest.[21] Clearly further information is needed.

Importance of post-cardiac arrest care

It is now clear that organised post-cardiac arrest care with emphasis on protocols for optimising cardiovascular and neurological care, including therapeutic hypothermia, can improve survival to hospital discharge among victims who achieve ROSC after cardiac arrest.[22,53,54] Although it is not yet possible to determine the individual effect of many of these therapies, it is clear that this "bundle of care" can improve outcome. Therapeutic hypothermia has been shown independently to improve outcome after adult witnessed out-of-hospital VF cardiac arrest and after neonatal hypoxic-ischaemic insult. Since 2005, two non-randomised studies with concurrent controls indicated possible benefit of hypothermia after cardiac arrest from other initial rhythms in-hospital and out-of-hospital,[55,56] and other studies with historic controls have shown benefit for therapeutic hypothermia after out-of-hospital all-rhythm cardiac arrests in adults.[22,57–60]

Studies of newborns with birth asphyxia[61,62] showed that therapeutic hypothermia (33.5–34.5 °C) up to 72 h after resuscitation has an acceptable safety profile and was associated with better survival and long-term neurological outcome. Retrospective studies of children following cardiac arrest failed to demonstrate benefit of therapeutic hypothermia, but a well-designed multicentre prospective randomised trial is in progress.

Many studies in recent years have attempted to identify comatose post-cardiac arrest patients who have no prospects of good neurological recovery.[63] It is now recognised that the use of therapeutic hypothermia invalidates the prognostication decision criteria that were established before hypothermia therapy was implemented: recent studies have documented occasional good outcomes in patients who would previously have met criteria predicting poor outcome (Cerebral Performance Category 3, 4, or 5).[64,65]

Education and implementation, including retraining

Basic and advanced life support knowledge and skills can deteriorate in as little as 3–6 months. Quality of education, frequent assessments and, when needed, refresher training are recommended to maintain resuscitation knowledge and skills.

Summary of the 2010 ILCOR Consensus on Science With Treatment Recommendations

Adult BLS

The 2010 International Consensus Conference addressed many questions related to the performance of BLS. These have been grouped into (1) epidemiology and recognition of cardiac arrest, (2) chest compressions, (3) airway and ventilation, (4) compression–ventilation sequence, (5) special situations, (6) EMS system, and (7) risks to the victim. Defibrillation is discussed separately in Part 6 because it is both a basic and an ALS skill.

There have been several important advances in the science of resuscitation since the 2005 ILCOR review. The following is a summary of the most important evidence-based recommendations for performance of BLS:

- Lay rescuers begin CPR if the adult victim is unresponsive and not breathing normally (ignoring occasional gasps) without assessing the victim's pulse.
- Following initial assessment, rescuers begin CPR with chest compressions rather than opening the airway and delivering rescue breathing.
- All rescuers, trained or not, should provide chest compressions to victims of cardiac arrest. A strong emphasis on delivering high-quality chest compressions remains essential: push hard to a depth of at least 2 in. or 5 cm at a rate of at least 100 compressions per minute, allow full chest recoil after each compression, and minimise interruptions in chest compressions.
- Trained rescuers should also provide ventilations with a compression–ventilation ratio of 30:2.
- EMS dispatchers should provide telephone instruction in chest compression-only CPR.

Epidemiology and recognition of cardiac arrest

Early recognition is a key step in initiating early treatment of cardiac arrest; this recognition requires identification of the most accurate method of determining cardiac arrest. In general rescuers should begin CPR if an adult is unresponsive and not breathing normally (disregarding occasional gasps). Healthcare providers cannot reliably determine the presence or absence of a pulse, so CPR should not be delayed if a pulse is not immediately found in the unresponsive adult victim who is not breathing normally. Lay rescuers cannot reliably determine the cause of an arrest, so it is not realistic to expect them to alter the response sequence to the likely aetiology of each arrest.

Chest compressions

Several components of chest compressions can alter effectiveness: hand position, position of the rescuer, position of the victim, compression depth, chest recoil, and duty cycle (see definition, below). Compression depth should at least be 2 in. (5 cm). Evidence for these techniques was reviewed in an attempt to define the optimal method.

Compressions only and compressions plus ventilations

All rescuers should perform chest compressions for all patients in cardiac arrest. Chest compressions alone are recommended for untrained laypersons responding to victims of cardiac arrest. Performing chest compressions alone is reasonable for trained laypersons if they are incapable of delivering airway and breathing

maneuver to cardiac arrest victims. Providing chest compressions with ventilations is reasonable for trained laypersons who are capable of giving CPR with ventilations to cardiac arrest victims.

Professional rescuers should provide chest compressions with ventilations for cardiac arrest victims. There is insufficient evidence to support or refute the effectiveness of the combination of chest compressions plus airway opening and oxygen inflation (compared with conventional CPR) by professional rescuers during the first few minutes of resuscitation from cardiac arrest.

Airway and ventilation

The best method of obtaining an open airway and the optimum frequency and volume of artificial ventilation were reviewed. The recommendations are unchanged from 2005.

Compression–ventilation sequence

In the 2005 International Consensus Conference recommendations, the recommended sequence of CPR actions was: airway, breathing, and circulation/chest compressions (ABC). In this 2010 document, in an attempt to shorten the delay to first chest compressions for adult victims, experts came to the consensus that rescuers may consider starting CPR with chest compressions rather than ventilations (the sequence will then be "CAB"). Rescuers should minimise interruptions in chest compressions during the resuscitation attempt.

Any recommendation for a specific CPR compression–ventilation ratio represents a compromise between the need to generate blood flow and the need to supply oxygen to the lungs and remove CO_2 from the blood. At the same time any such ratio must be taught to would-be rescuers, so the effect of compression–ventilation ratios on skills acquisition and retention must be considered. A compression–ventilation ratio of 30:2 remains reasonable for an adult victim of cardiac arrest when no advanced airway is in place.

Special situations (cervical spine injury, facedown)

It is reasonable to roll a victim who is facedown and unresponsive to the supine position to assess breathing and initiate resuscitation. Concern for protecting the neck should not hinder the evaluation process or life saving procedures.

EMS system

Recognition of cardiac arrest as the cause of collapse is rarely simple and requires EMS dispatchers to elicit critical information from the caller. Failure to recognise the true cause of the collapse occurs in as many as 50% of cases of cardiac arrest; this failure precludes the implementation of bystander CPR and lowers the victim's chance of survival.[66]

When attempting to identify a cardiac arrest victim, the EMS dispatcher should inquire about the victim's absence of consciousness and quality of breathing (normal/not normal). Dispatchers should be specifically educated about identification of abnormal breathing in order to improve recognition of adult cardiac arrest. The correct identification of cardiac arrest may be increased by careful attention to the caller's spontaneous comments and by focused questions, including questions about seizures and gasping.

Bystanders who call their local emergency response number should receive initial instructions on performing CPR. Dispatchers should provide compression-only CPR instructions to untrained rescuers for adults with suspected sudden cardiac arrest. If a dispatcher suspects asphyxial arrest, it is reasonable to provide instructions for rescue breathing followed by chest compressions. Quality-improvement efforts should assess the accuracy and timeliness of dispatcher recognition of cardiac arrest and the delivery of CPR instructions.

Risks to the victim

Many rescuers are concerned that delivering chest compressions to a victim who is not in cardiac arrest will lead to serious complications, and thus they do not initiate CPR for some victims of cardiac arrest. In individuals with presumed cardiac arrest, bystander CPR rarely leads to serious harm in victims who are eventually found not to be cardiac arrest; therefore, performance of bystander CPR should be strongly encouraged.[67]

Defibrillation

The Defibrillation Task Force considered many questions related to adult defibrillation. In general, the 2010 International Consensus Conference recommendations contain no major differences from the 2005 recommendations. The questions have been grouped into the following categories: (1) CPR before defibrillation, (2) electrode–patient interface, (3) defibrillation strategy, (4) special situations, and (5) related defibrillation topics.

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

CPR before defibrillation

Whether a period of CPR should be performed before defibrillation in VF, especially after long response times, continues to be the subject of intense debate. The theoretical rationale for performing CPR before shock delivery is to improve coronary perfusion and thereby the chances of achieving sustained ROSC; however, there is inconsistent evidence to support or refute a delay in defibrillation to provide a period (90 s to 3 min) of CPR for patients in VF/pulseless ventricular tachycardia (VT) cardiac arrest. If more than one rescuer is present, one rescuer should provide chest compressions while the other activates the emergency response system, retrieves the AED and prepares to use it.

Electrode–patient interface

There are only a few studies comparing differences in outcome associated with use of different electrode–patient interfaces; many studies compare secondary end points such as the effect on transthoracic impedance. In ventricular arrhythmias there is no evidence to suggest that transthoracic impedance affects shock success. When using biphasic defibrillators for both pulseless VT/VF defibrillation and conversion of atrial fibrillation, self-adhesive defibrillator pads are safe and effective and are an acceptable alternative to standard defibrillation paddles. Hand-held paddles are preferable when using monophasic defibrillators for cardioversion of atrial fibrillation.

It is reasonable to place paddles or pads on the exposed chest in an anterolateral position. Acceptable alternative positions are the anteroposterior (paddles and pads) and apex-posterior (pads). There is insufficient evidence to make specific recommendations for the optimal electrode size for external defibrillation; however, it is reasonable to use a pad size <8 cm for adults. In terms of cardiac arrest outcomes there is insufficient evidence to recommend a specific composition of the conductive material of defibrillation electrodes.

Defibrillation strategy

All new defibrillators deliver shocks using a variety of biphasic waveforms. Although it has not been demonstrated conclusively in randomised 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 s after the shock. There is insufficient evidence to recommend any specific biphasic waveform. In the absence of biphasic defibrillators, monophasic defibrillators are acceptable.

Several different biphasic waveforms exist, but no human studies have compared different biphasic waveforms and different energy levels related to defibrillation success or survival. For all waveforms insufficient evidence exists to make clear recommendations; however, it is reasonable to start at an energy level of 150–200 J for biphasic truncated exponential 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.

When defibrillation is required, a single shock should be provided with resumption of chest compressions/CPR immediately after the shock. Chest compressions should not be delayed for rhythm reanalysis or a pulse check immediately after a shock. CPR should not be interrupted until rhythm reanalysis is undertaken. For second and subsequent biphasic shocks the same initial energy level is acceptable. It is reasonable to increase the energy level when possible.

There are no survival differences between defibrillation in semiautomatic and manual modes during in-hospital or out-of-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 minimising the preshock pause. For rescuers using the defibrillator in manual mode, electrocardiographic recognition skills are essential and frequent team training is helpful. The defibrillation mode (semiautomatic versus manual) that results in the best outcome will be influenced by the system, the provider's skills and training, and accuracy of electrocardiographic recognition.

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) for cardioversion when using biphasic defibrillators. For cardioversion using monophasic defibrillators a high initial energy (360 J) seems preferable.

Electrical therapy in special situations

Electric pacing is not effective as a 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 haemodynamically unstable bradyarrhythmias until an electric pacemaker (transcutaneous or transvenous) is available. The use of epicardial wires to pace the myocardium after cardiac surgery is effective.

In patients with an implantable cardioverter-defibrillator (ICD) or a permanent pacemaker, the placement of pads/paddles should not delay defibrillation. The defibrillator pad/paddle should be placed on the chest wall ideally at least 8 cm from the generator position. Anterior–posterior and anterior–lateral pad/paddle placements on the chest are acceptable in patients with an ICD or a permanent pacemaker.

Related defibrillation topics

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

Rescuers should take precautions to minimise sparking (by careful pad/paddle placement, prevention of contact, etc.) during attempted defibrillation. Rescuers should try to ensure that defibrillation is not attempted in an oxygen-enriched atmosphere.

CPR techniques and devices

The success of any technique or device depends on the education and training of the rescuers. A device or technique that provides good-quality CPR and potentially better outcome when used by a highly trained team or in a test setting may result in frequent interruptions in CPR when used in an actual clinical setting.[18] As with any clinical practice intervention, the process must be monitored to assess for unintended adverse consequences.

Although no circulatory adjunct is currently recommended as preferable to manual CPR for routine use, some circulatory adjuncts are being used in both out-of-hospital and in-hospital resuscitation attempts. 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: interposed abdominal compression CPR, active compression–decompression CPR, open-chest CPR, load-distributing band CPR, mechanical piston (thumper) CPR, Lund University Cardiac Arrest System (LUCAS) CPR, and the impedance threshold device (ITD). Interposed abdominal compression CPR has not been studied in humans since 1994. Active compression–decompression (ACD) CPR has not been studied in humans since 1999, although a meta-analysis comparing ACD CPR with standard CPR was published in 2004 and showed no significant increase in rates of immediate survival or hospital discharge.[68]

There are insufficient data to support or refute the routine use of open-chest CPR, load-distributing band CPR, LUCAS CPR, mechanical piston CPR, or the ITD instead of standard CPR. On the basis of case reports and case series[69] it may be reasonable to consider load-distributing band or LUCAS CPR to maintain continuous chest compressions while the patient undergoes percutaneous coronary intervention (PCI) or computed tomography (CT) or similar diagnostic studies when provision of manual CPR would be difficult.

ALS

The ILCOR ALS Task Force reviewed the topics of (1) airway and ventilation, (2) support of circulation during cardiac arrest, (3) peri-arrest arrhythmias, (4) cardiac arrest in special situations, (5) identification of reversible causes, (6) post-cardiac arrest care, (7) prognostication, and (8) organ donation.

The most important developments and recommendations in ALS since the 2005 ILCOR review have been:

- The use of capnography to confirm and continually monitor tracheal tube placement and quality of CPR.
- More precise guidance on control of glucose in adults with sustained ROSC. Blood glucose values >180 mg dL^{-1} (>10 mmol L^{-1}) should be treated and hypoglycaemia avoided.
- Additional evidence, albeit lower level, for use of therapeutic hypothermia for comatose survivors of cardiac arrest initially associated with nonshockable rhythms.
- Recognition that many accepted predictors of poor outcome in comatose survivors of cardiac arrest are unreliable, especially if

the patient has been treated with therapeutic hypothermia. There is inadequate evidence to recommend a specific approach to predicting poor outcome in post-cardiac arrest patients treated with therapeutic hypothermia.
- The recognition that adults who progress to brain death after resuscitation from out-of-hospital cardiac arrest (OHCA) should be considered for organ donation.
- The recommendation that implementation of a comprehensive, structured treatment protocol may improve survival after cardiac arrest.

Airway and ventilation

Consensus conference topics related to the management of airway and ventilation are categorised as basic airway devices, cricoid pressure, advanced airway devices, confirmation of advanced airway placement, oxygenation, and strategies for ventilation. The use of oropharyngeal and nasopharyngeal airways has never been studied in cardiac arrest, but their use in this context remains reasonable.

The routine use of cricoid pressure to prevent aspiration in cardiac arrest is not recommended. If cricoid pressure is used during cardiac arrest, the pressure should be adjusted, relaxed, or released if it impedes ventilation or placement of an advanced airway.

The tracheal tube was once considered the optimal method of managing the airway during cardiac arrest. There is considerable evidence that without adequate training or ongoing skills maintenance, the incidence of failed intubations and complications (e.g., unrecognised oesophageal intubation or unrecognised dislodgment) is unacceptably high.[70–75] Prolonged attempts at tracheal intubation are harmful because the cessation of chest compressions during this time will compromise coronary and cerebral perfusion. Alternatives to the tracheal tube that have been studied during actual and manikin CPR include the bag and mask and supraglottic airway devices such as the laryngeal mask airway (LMA), Combitube, the laryngeal tube, and the I-gel. Studies comparing the supraglottic airway with tracheal intubation have generally compared insertion time and ventilation success rates. No study has shown an effect of the method of ventilation on survival.

There are no data to support the routine use of any specific approach to airway management during cardiac arrest. The best approach depends on the precise circumstances of the cardiac arrest and the competence of the rescuer. There is inadequate evidence to define the optimal timing of advanced airway placement during cardiac arrest. Healthcare professionals trained to use supraglottic airway devices may consider their use for airway management during cardiac arrest and as a backup or rescue airway in a difficult or failed tracheal intubation.

Waveform capnography is recommended to confirm and continuously monitor the position of a tracheal tube in victims of cardiac arrest and it should be used in addition to clinical assessment (auscultation and direct visualization are suggested).

If waveform capnography is not available, a nonwaveform CO_2 detector or oesophageal detector device in addition to clinical assessment can be used. Thoracic impedance may be used as an adjunctive measure to diagnose airway placement in patients with cardiac arrest; however, clinical decisions should not be based solely on thoracic impedance measurement until further study has confirmed its utility and accuracy in this population.

There is insufficient evidence to support or refute the use of a titrated oxygen concentration or constant 21% oxygen (room air) when compared with 100% oxygen during adult cardiac arrest. In the absence of other data, there is no reason to change the current treatment algorithm, which includes use of 100% oxygen during adult cardiac arrest.

There is insufficient evidence to support or refute the use of passive oxygen delivery during CPR to improve outcomes (ROSC, hospital discharge rate, and improved neurological survival) when compared with oxygen delivery by positive-pressure ventilation.

There is insufficient evidence to support or refute monitoring peak pressure and minute ventilation to improve outcome from cardiac arrest. There is indirect evidence that monitoring the respiratory rate with real-time feedback is effective in avoiding hyperventilation and achieving ventilation rates closer to recommended values, but there is no evidence that ROSC or survival is improved. Continuous capnography or capnometry monitoring if available may be beneficial by providing feedback on the effectiveness of chest compressions.

Support of circulation during cardiac arrest

Questions related to circulatory support during cardiac arrest that were discussed during the 2010 International Consensus Conference were categorised as (1) timing of drug delivery, (2) use of vasopressors during cardiac arrest, (3) use of other drugs during cardiac arrest, (4) use of intravenous (IV) fluids, and (5) provision of extracorporeal support. It is recognised that the vast majority of studies assessing the effects of drugs on survival have not been able to control for the quality of CPR. Furthermore, most drug evaluations to date have been conducted before recent advances in post-cardiac arrest care, including therapeutic hypothermia. Because most drug trials have, at most, demonstrated only short-term outcome advantage, it may be important to evaluate long-term outcome when these drugs are combined with optimised post-cardiac arrest care. One study compared the use of IV access and drugs (epinephrine, amiodarone, atropine, vasopressin, without isolating the effect of each individual drug alone), with no IV access and no drugs in adult out-of-hospital CPR. There was demonstrated improvement in ROSC and survival to hospital and intensive care unit admission but no difference in survival to discharge or neurological outcomes at discharge and 1-year follow-up.[21] However, this study was not powered to detect clinically meaningful differences in long-term outcome. Similarly, one study[76] with a "before and after" design compared various outcomes after OHCA and was not able to demonstrate any improvements after introduction of ALS (epinephrine, atropine, lidocaine). Neither of these studies is able to isolate outcomes specifically related to individual drug administration.

There is inadequate evidence to define the optimal timing or order for drug administration. Despite the continued widespread use of epinephrine and increased use of vasopressin during resuscitation in some countries, there is no placebo-controlled study that shows that the routine use of any vasopressor during human cardiac arrest increases survival to hospital discharge. There is no evidence that the routine use of other drugs (e.g., atropine, amiodarone, lidocaine, procainamide, magnesium, buffers, calcium, hormones, or fibrinolytics) during human CPR increases survival to hospital discharge. There is insufficient evidence to recommend for or against the routine infusion of IV fluids during resuscitation from cardiac arrest. There is also insufficient evidence to support or refute the routine use of extracorporeal CPR in cardiac arrest.

Peri-arrest arrhythmias

Narrow-complex tachycardia (excluding atrial fibrillation). There are 4 options for the treatment of narrow-complex tachycardia in the peri-arrest setting: electric conversion, physical maneuvers, pharmacological conversion, and rate control. The treatment choice depends on the stability of the patient and the

rhythm. In a haemodynamically unstable patient, narrow-complex tachycardia is best treated with electric cardioversion; otherwise, vagal maneuvers, IV adenosine, verapamil, and diltiazem are recommended as first-line treatment strategies. Nadolol, sotalol, propafenone, and amiodarone may be considered.

Atrial fibrillation. Patients with atrial fibrillation who are haemodynamically unstable should receive prompt electric cardioversion.

Rate control. β-Blockers and diltiazem are the drugs of choice for acute rate control in most patients with atrial fibrillation and rapid ventricular response. Digoxin and amiodarone may be used in patients with congestive heart failure; amiodarone may also result in cardioversion to normal sinus rhythm. Magnesium and clonidine have rate-controlling effects, although there are fewer supporting data for their use.

Rhythm control. Chemical cardioversion can be achieved with ibutilide, dofetilide, and flecainide. Amiodarone can also be used for chemical cardioversion but is less effective. Quinidine or procainamide may be useful for cardioversion, but their use is less well-established. Propafenone is more effective than placebo but not as effective as amiodarone, procainamide, or flecainide. There is no role for digoxin in chemical cardioversion.

Wide-complex tachycardia. There are 2 options for treatment of wide-complex tachycardia in the peri-arrest setting: electric conversion and chemical conversion. The choice depends on the stability of the patient and the rhythm. In a haemodynamically unstable patient, wide-complex tachycardia is best treated with electric cardioversion.

Procainamide is recommended for patients with haemodynamically stable monomorphic VT (mVT) who do not have severe congestive heart failure or acute myocardial infarction (AMI). Amiodarone is recommended for patients with haemodynamically stable mVT with and without either severe congestive heart failure or AMI. Sotalol may be considered for patients with haemodynamically stable sustained mVT, including patients with AMI.

In undifferentiated regular stable wide-complex tachycardia, IV adenosine may be considered relatively safe, may convert the rhythm to sinus, and may help diagnose the underlying rhythm.

Polymorphic wide-complex tachycardia associated with familial long QT syndrome may be treated with IV magnesium, pacing, and β-blockers; however, isoproterenol should be avoided. Polymorphic wide-complex tachycardia associated with acquired long QT syndrome may be treated with IV magnesium. The addition of pacing or IV isoproterenol may be considered when polymorphic wide-complex tachycardia is accompanied by bradycardia or appears to be precipitated by pauses in rhythm. Polymorphic wide-complex tachycardia without long QT syndrome may be responsive to IV β-blockers (ischaemic VT; catecholaminergic VT) or isoproterenol.

Bradycardia. In the peri-arrest setting the rescuer should seek and treat reversible causes of bradycardia. In the absence of immediately reversible causes, atropine remains the first-line drug for acute symptomatic bradycardia. If not effective, then consider isoproterenol, epinephrine, dopamine, or transcutaneous pacing.

Cardiac arrest in special situations

The ALS Task Force reviewed special situations associated with cardiac arrest, including avalanche, pregnancy, asthma, anaphylaxis, drug overdose and poisoning, coronary catheterisation, heart surgery, cardiac tamponade, pulmonary embolus, and electrolyte disorders.

Cardiac arrest caused by avalanche

Avalanches occur in areas that are difficult for rescuers to access and frequently involve multiple victims. The decision to initiate full resuscitative measures should be determined by the number of victims and the resources available and should be informed by the likelihood of survival. A victim buried by an avalanche is unlikely to survive if the victim has been buried for >35 min, the airway is obstructed on extrication and the initial core temperature is <32°, or the victim has an initial serum potassium level >7 mmol L^{-1}.

Cardiac arrest associated with pregnancy

There is insufficient evidence to support or refute the use of specialised obstetric resuscitation techniques in maternal cardiac arrest or the use of therapeutic hypothermia in the postarrest period. Treatment may be guided by understanding the physiology of pregnancy, the importance of releasing aortocaval compression, the increased risk for hypovolaemia, the optimal positioning for compressions, and the value of perimortem caesarean section early in maternal cardiac arrest.

Cardiac arrest caused by asthma, anaphylaxis, or electrolyte disorders

There is insufficient evidence to suggest any routine change to resuscitation treatment algorithms for patients with cardiac arrest caused by asthma, anaphylaxis, or electrolyte disorders.

Cardiac arrest caused by drug overdose and poisoning

The majority of questions concerning cardiac arrest caused by drug toxicity remain unanswered. The 2010 International Consensus Conference reviewed treatment of cardiac arrest caused by local anesthesia, benzodiazepines, β-blockers, calcium channel blockers, carbon monoxide, cocaine, cyanide, tricyclic antidepressants, digoxin, and opioids.

Cardiac arrest during coronary catheterisation

There are no randomised controlled trials evaluating alternative treatment strategies versus standard care for cardiac arrest during PCI. Evidence is limited to case studies for all interventions; thus, the data are insufficient to support or refute the use of mechanical chest compression, cough CPR, or emergency cardiopulmonary bypass to improve outcome of cardiac arrest during PCI.

Cardiac arrest after open or closed heart surgery

Resternotomy for patients with cardiac arrest following cardiac surgery should be considered in an appropriately staffed and equipped intensive care unit or in the operating suite. Resternotomy performed outside of these specialised environments has poor results. Chest compressions should not be withheld while preparing for emergency resternotomy. Mechanical circulatory support may be considered in the setting of cardiac arrest following cardiac surgery. There is insufficient evidence to make any recommendations about epinephrine dose, use of antiarrhythmics, or any other intervention separate from those recommended in standard protocols.

Cardiac arrest caused by cardiac tamponade

Pericardiocentesis guided by echocardiography should be considered for the treatment of cardiac arrest associated with cardiac tamponade. Non-image-guided pericardiocentesis is an acceptable alternative if echocardiography is not available. Emergency department thoracotomy and pericardiotomy are acceptable alternatives to operating suite thoracotomy and pericardiotomy for treatment of traumatic cardiac arrest associated with cardiac tamponade and can be considered for use in the treatment of nontraumatic cardiac

arrest when pericardiocentesis is unsuccessful in relieving cardiac tamponade.

Cardiac arrest caused by pulmonary embolus

Fibrinolytic therapy may be considered when pulmonary embolism is suspected as the cause of the cardiac arrest.

Identification of reversible causes

Ultrasound during cardiac arrest

Although there are several case series, no studies specifically examine the impact of ultrasound or echocardiography on patient outcomes in cardiac arrest.

Post-cardiac arrest care

Post-cardiac arrest treatment protocol

Before-and-after studies report an increase in survival of comatose patients with sustained ROSC after OHCA with implementation of a comprehensive treatment protocol.[22,53,54] Protocols include multiple elements such as hypothermia, glucose control, goal-directed haemodynamic optimisation, ventilation, and PCI. The independent effect of each element of the bundle of care could not be established.

Treatment of pulmonary embolism after ROSC

In patients with diagnosed or suspected pulmonary embolism after ROSC following cardiac arrest, there is inadequate evidence to recommend for or against the use of fibrinolytic therapy in addition to heparin. The mortality with surgical embolectomy for suspected or diagnosed pulmonary embolism is high if it follows cardiac arrest. Surgical embolectomy should be avoided in patients who have received CPR. There are few data on percutaneous mechanical thromboembolectomy, but it may be beneficial and may be considered in patients with cardiac arrest resulting from a pulmonary embolism who are not candidates for fibrinolytic therapy.

Ventilation

After restoration of circulation, routine hyperventilation leading to hypocapnia should be avoided to prevent additional cerebral ischaemia.

Controlled oxygenation

There is insufficient clinical evidence to support or refute the use of titrated inspired oxygen content in the early care of cardiac arrest patients following sustained ROSC.

Support of circulation

Fluid therapy. There is insufficient evidence to support or refute the routine use of IV fluids following sustained ROSC after cardiac arrest. Rapid infusion with cold 0.9% saline or lactated Ringer's solution appears to be well-tolerated when used to induce therapeutic hypothermia. On the basis of the pathophysiology of post-cardiac arrest syndrome, it is reasonable to use IV fluids as part of a package of post-cardiac arrest care.

Haemodynamic optimisation. There are no published randomised controlled trials of early haemodynamic optimisation after cardiac arrest. Despite limited clinical data, the known pathophysiology of post-cardiac arrest syndrome provides a rationale for titrating haemodynamic support to optimise organ perfusion.

Cardioactive drugs. No clinical trials have determined or compared the independent effect of vasopressor or inotrope use in the post-cardiac arrest period on cardiovascular dysfunction and survival to discharge. There is insufficient evidence to support or refute the routine use of vasopressors and inotropes for improving survival in adult patients with cardiovascular dysfunction after resuscitation from cardiac arrest.

Antiarrhythmic drugs. No controlled studies have specifically addressed the use of amiodarone, lidocaine, or β-blockers early or immediately after resuscitation from cardiac arrest. There is no evidence to support or refute continued administration of amiodarone or lidocaine in post-cardiac arrest patients following ROSC.

Mechanical circulatory support. There are no studies directly addressing the use of mechanical circulatory support in patients with sustained ROSC who have cardiovascular dysfunction.

Temperature control

Prevention and treatment of hyperthermia. There are no randomised controlled trials evaluating the effect of treatment of pyrexia (defined as $\geq$37.6 °C) compared with no temperature control in patients after cardiac arrest. However, it is well-established that patients who develop hyperthermia after cardiac arrest have a worse prognosis. Despite the lack of evidence, it is reasonable to treat hyperthermia if it occurs in the postresuscitation period.

Therapeutic hypothermia. Adult patients who are comatose (not responding in a meaningful way to verbal commands) with spontaneous circulation after out-of-hospital VF cardiac arrest should be cooled to 32–34 °C for 12–24 h. Induced hypothermia might also benefit comatose adult patients with spontaneous circulation after OHCA from a nonshockable rhythm or in-hospital cardiac arrest. Rapid infusion of ice-cold IV fluid at 30 mL kg^{-1} is a safe, feasible, and simple method for initially lowering core temperature by up to 1.5 °C, as is application of ice packs. When IV fluids are used to induce hypothermia, additional cooling strategies will be required to maintain hypothermia. Limited available evidence suggests that PCI during therapeutic hypothermia is feasible and safe and may be associated with improved outcome.

Seizure control

No controlled clinical trials directly addressed prophylactic treatment for seizures after cardiac arrest; consequently, there are insufficient data to support or refute the use of specific antiseizure medication in the prevention or treatment of seizures after ROSC.

Other supportive therapies

Blood glucose control. Strategies to treat hyperglycaemia that is >180 mg dL^{-1} (>10 mmol L^{-1}) should be considered in adult patients with sustained ROSC after cardiac arrest. Hypoglycaemia should be avoided.

Neuroprotective therapy. The value of routine use of coenzyme Q10 in patients treated with hypothermia is not certain. There are insufficient data to recommend for or against the use of neuroprotective drugs (thiopental, glucocorticoids, nimodipine, lidoflazine, or diazepam) alone or as an adjunct to therapeutic hypothermia in comatose cardiac arrest after ROSC.

Prognostication

Prognostication during cardiac arrest

End-tidal CO_2 and prediction of outcome. Quantitative measurement of end-tidal CO_2 may be a safe and effective noninvasive indicator of cardiac output during CPR and an abrupt increase in end-tidal CO_2 may be an early indicator of ROSC in intubated patients. Although low values of end-tidal CO_2 are associated with

a low probability of survival, there are insufficient data to support or refute a specific threshold of end-tidal CO_2 at different time intervals as a prognostic indicator of outcome during adult cardiac arrest.

Prognostication after resuscitation

Clinical examination. There are no clinical neurological signs that reliably predict poor outcome <24 h after cardiac arrest. In adult patients who are comatose after cardiac arrest, have not been treated with hypothermia and have no confounding factors (e.g., hypotension, sedatives or neuromuscular blockers), the absence of both pupillary light and corneal reflex at ≥72 h reliably predicts poor outcome. The absence of vestibulo-ocular reflexes at ≥24 h and a Glasgow Coma Scale (GCS) motor score of 2 or less at ≥72 h are less reliable predictors. Other clinical signs, including myoclonus, are not recommended for predicting poor outcome.

Biochemical markers. Evidence does not support the use of serum or cerebrospinal fluid biomarkers alone as predictors of poor outcome in comatose patients after cardiac arrest with or without treatment with therapeutic hypothermia. Limitations of studies included small numbers of patients or inconsistency in threshold values for predicting poor outcome.

Electrophysiological studies. No electrophysiological study reliably predicts outcome of comatose patients in the first 24 h after cardiac arrest when therapeutic hypothermia is not used. After 24 h, bilateral absence of the N20 cortical response to median nerve stimulation predicts poor outcome in comatose cardiac arrest survivors not treated with therapeutic hypothermia. In the absence of confounding circumstances such as use of sedatives or the presence of hypotension, hypothermia, or hypoxaemia, it is reasonable to use unprocessed electroencephalography (EEG) interpretation (specifically identifying generalised suppression to <20 μV, burst suppression pattern with generalised epileptic activity, or diffuse periodic complexes on a flat background) observed between 24 and 72 h after sustained ROSC to assist in prediction of a poor outcome in comatose survivors of cardiac arrest not treated with hypothermia.

Imaging studies. Many imaging modalities have been studied to determine their utility for prediction of outcome in survivors of adult cardiac arrest. There are no level 1 or level 2 studies that support the use of any imaging modality to predict outcome of comatose cardiac arrest survivors. In general, published imaging studies were limited by small sample sizes, variable time of imaging (many very late in the course), lack of comparison with a standardised method of prognostication, and early withdrawal of care. Despite tremendous potential, neuroimaging has yet to be proven as an independently accurate modality for prediction of outcome in individual comatose cardiac arrest survivors, and at this time there is insufficient evidence to recommend for or against the routine use of imaging studies used for this purpose.

Impact of therapeutic hypothermia on accuracy of post-cardiac arrest prognostication. There is inadequate evidence to recommend a specific approach to prognosticating poor outcome in post-cardiac arrest patients treated with therapeutic hypothermia. There are no clinical neurological signs, electrophysiological studies, biomarkers, or imaging modalities that can reliably predict neurological outcome in the first 24 h after cardiac arrest. Beyond 24 h no single parameter for predicting poor neurological outcome in post-cardiac arrest patients treated with hypothermia is sufficiently specific.

On the basis of the limited available evidence, potentially reliable prognosticators of poor outcome in patients treated with therapeutic hypothermia after cardiac arrest include bilateral absence of N20 peak on somatosensory evoked potential ≥24 h after cardiac arrest, unreactive EEG background at 36–72 h, and the absence of both corneal and pupillary reflexes >72 h after cardiac arrest. Limited available evidence also suggests that (1) a GCS motor score of 2 or less at 3 days after sustained ROSC and (2) the presence of status epilepticus are potentially unreliable prognosticators of poor outcome in post-cardiac arrest patients treated with therapeutic hypothermia. Serum biomarkers such as neuron-specific enolase are potentially valuable as adjunctive studies in prognostication of poor outcome in patients treated with hypothermia, but their reliability is limited by the relatively few patients who have been studied and lack of assay standardisation. Given the limited available evidence, decisions to limit care should not be made based on the results of a single prognostication tool.

Organ donation

Several studies have suggested no difference in functional outcomes of organs transplanted from patients who were determined to be brain-dead as a consequence of cardiac arrest when compared with organs recovered from donors who were brain-dead from other causes.[77–79] Thus, adult patients who progress to brain death after resuscitation from OHCA should be considered for organ donation.

Acute coronary syndromes

The Acute Coronary Syndromes Task Force reviewed the evidence related to the diagnosis and treatment of ACS in the out-of-hospital setting and during the first hours of care in hospital, typically in the emergency department (ED). The ACS Task Force reviewed the following topics: (1) diagnostic tests in ACS, (2) initial therapeutic interventions, (3) reperfusion strategies, (4) additional medical therapy, and (5) healthcare system interventions for ACS.

The following are the most important 2010 changes in recommendations for diagnosis and treatment of ACS.[80,81]

- The history and physical examination, initial ECG, and initial serum biomarkers, even when used in combination, cannot be used to reliably exclude ACS in the prehospital and ED settings.
- In contrast, chest pain observation protocols are useful for identifying patients with suspected ACS who require admission or may be referred for provocative testing for coronary artery disease (CAD) to identify reversible ischaemia. Such strategies also reduce cost by reducing unnecessary hospital admissions and improve patient safety through accurate identification of non-ST-segment elevation myocardial infarction (NSTEMI) and ST-segment elevation myocardial infarction (STEMI).
- The acquisition of a prehospital 12-lead ECG is essential for identification of STEMI patients before hospital arrival and should be used in conjunction with prearrival hospital notification and concurrent activation of the catheterisation laboratory.
- Nonphysicians can be trained to independently interpret 12-lead ECGs to identify patients with STEMI. This skill is of particular value in the prehospital setting, where paramedics can independently identify STEMI, thus reducing the need for ECG transmission, which is not always possible.
- Computer-assisted ECG interpretation can be used to increase diagnostic accuracy of diagnosis for STEMI when used alone or in combination with ECG interpretation by a trained healthcare provider.
- STEMI systems of care can be implemented to improve the time to treatment. The following measures have been shown to reduce

the time to primary PCI (PPCI): institutional commitment, use of a team-based approach, arranging single-call activation of the catheterisation laboratory by the emergency physician or prehospital provider, requiring the catheterisation laboratory to be ready in 20 min, having an experienced cardiologist always available, and providing real-time data feedback.
- IV β-blockers should not be given routinely in the ED or prehospital setting but rather should be reserved for a subset of patients with hypertension or tachycardia in the setting of ACS.
- The routine use of high-flow supplementary oxygen in ACS is not recommended. Instead oxygen administration should be guided by arterial oxyhaemoglobin saturation.
- Reinforce the need for time targets for reperfusion beginning from the time of first medical contact. The clinical circumstances that favor fibrinolysis and PCI are discussed, including the role of prehospital fibrinolytics.
- The prophylactic use of antiarrhythmics is discouraged.
- Immediate angiography and PCI should be considered in patients with OHCA and ROSC. It is reasonable to perform immediate angiography and PCI in selected patients, despite the absence of ST-segment elevation on the ECG or prior clinical findings such as chest pain.

Diagnostic tests in ACS

Risk stratification

Various factors may impede patients from rapidly seeking treatment. These factors include older age, race and ethnicity, female sex, low socioeconomic status, and whether the patient lives alone. Signs and symptoms alone are neither sensitive nor specific and should not be used without other data for diagnosing ACS. Signs and symptoms may be useful in combination with other important information (biomarkers, risk factors, ECG, and other diagnostic tests) in making triage and some treatment and investigational decisions for ACS in the out-of hospital and ED settings. A reduction in chest pain after administration of nitroglycerin may be unrelated to the presence or absence of ACS and should not be used as a diagnostic test or strategy in the prehospital or ED setting.

ED interpretation of 12-lead ECG for STEMI

In patients with suspected ACS, a 12-lead-ECG should be acquired and interpreted by prehospital or emergency providers as soon as possible after first patient contact. The interpretation should be used for diagnosis and triage, including destination decisions and activation of the cardiac catheterisation laboratory. If interpretation of the prehospital ECG is not available on-site, field transmission of the ECG for expert interpretation may be reasonable. It is reasonable for paramedics and nurses to independently identify STEMI on a 12-lead ECG provided there is a program of mandatory initial training followed by ongoing concurrent medical oversight of all interpretations. Prehospital ECG interpretation should be augmented with computer interpretation. Computer interpretation of the ECG may increase the specificity of diagnosis of STEMI, especially for clinicians less experienced in reading ECGs. The computer interpretation should be considered in the clinical context.

Diagnostic and prognostic test characteristics of cardiac biomarkers for ACS

Clinicians should consider the time of symptom onset, sensitivity, precision and institutional norms of the assay, and release kinetics and clearance of the measured biomarker. For all patients presenting to the ED with symptoms suggestive of cardiac ischaemia, cardiac biomarker testing should be part of the initial evaluation. A cardiac-specific troponin is the preferred biomarker. For patients who present within 6 h of onset of symptoms suggestive of cardiac ischaemia with initially negative cardiac troponin, it is recommended that the troponin level be remeasured between 6 and 12 h after symptom onset. Multimarker evaluation with creatine kinase MB (CK-MB) or myoglobin in conjunction with troponin in patients with symptoms suggestive of cardiac ischaemia may be considered to improve the sensitivity of AMI diagnosis. There is no evidence to support the use of troponin point-of-care testing (POCT) in isolation as a primary test in the prehospital setting to evaluate patients with symptoms suggestive of cardiac ischaemia.

There is insufficient evidence to support the use of myoglobin, brain natriuretic peptide (BNP), NT-proBNP, D-dimer, C-reactive protein, ischaemia-modified albumin pregnancy-associated plasma protein A (PAPP-A), or interleukin-6 in isolation as primary tests to evaluate patients with symptoms suggestive of cardiac ischaemia.

None of the currently reported clinical decision rules is adequate and appropriate for identifying ED chest pain patients who can be safely discharged from the ED. Patients who are less than 40 years of age with nonclassical presentations and lacking significant past medical history and normal serial biomarkers and 12-lead ECGs have a very low rate of short-term events.

In ED patients with suspected ACS, normal initial biomarkers, and a nonischaemic ECG, chest pain observation protocols may be recommended as a safe and effective strategy for evaluation. Chest pain observation protocols should include a history and physical examination, a period of observation, serial ECGs, serial measurement of serum cardiac markers, and either an evaluation for anatomic coronary disease or inducible myocardial ischaemia some time after AMI is excluded. These protocols may be used to improve accuracy in differentiating patients requiring inpatient admission or further diagnostic testing from those who may be discharged. Chest pain protocols may be recommended as a means to reduce length of stay, reduce hospital admissions, reduce healthcare costs, improve diagnostic accuracy, and improve quality of life. There is no direct evidence demonstrating that chest pain units (CPUs) or observation protocols reduce adverse cardiovascular outcomes, particularly mortality, for patients presenting with possible ACS, normal serum cardiac biomarkers, and a nondiagnostic ECG.

Imaging techniques

For ED patients with suspected ACS, nonischaemic ECGs, and negative biomarkers, a noninvasive test (CT angiography, cardiac magnetic resonance imaging [MRI], myocardial perfusion imaging, and echocardiography) can be useful in making the diagnosis of ACS. Diagnostic imaging may be considered as an adjunct to serial ECGs and biomarkers to identify patients who either require admission or are suitable for discharge from the ED. These noninvasive tests decrease costs, length of stay, and time to diagnosis and can provide valuable short- and long-term prognostic information on future major cardiac events. However, there are insufficient data on mortality.

Initial therapeutic interventions

Oxygen therapy

There is insufficient evidence to support or refute the empirical use of high-flow oxygen therapy in patients with uncomplicated AMI without signs of hypoxaemia or heart failure. There are insufficient data to determine if high-flow oxygen therapy might be harmful in this setting. Oxygen therapy should be initiated if dyspnoea, hypoxaemia, or signs of heart failure or shock are present. Noninvasive monitoring of arterial blood oxygen saturation may be used to determine the need for oxygen administration.

ACS and nitroglycerin

Although it is reasonable to consider the early administration of nitroglycerin in selected patients without contraindications, insufficient evidence exists to support or refute the routine administration of nitroglycerin in patients with suspected ACS. There may be some benefit if nitroglycerin administration results in pain relief.

Analgesics and sedation

Morphine should be given IV and titrated to pain relief in patients with STEMI. Morphine may be considered for pain relief in subjects with suspected NSTEMI. Some form of analgesia should be considered for patients with active chest discomfort. Although anxiolytics may be administered to patients with ACS to alleviate apprehension and anxiety, there is no evidence that anxiolytics facilitate ECG resolution, reduce infarct size, or decrease mortality in undifferentiated patients with suspected ACS. Lorazepam with nitroglycerin may be considered to alleviate pain in patients with cocaine-associated chest pain. Nonsteroidal anti-inflammatory drugs (NSAIDs) other than aspirin should not be administered and may be harmful in patients with suspected ACS; NSAIDs should be discontinued in such patients when feasible.

Aspirin

In the absence of true allergy, aspirin should be given as soon as possible to patients with suspected ACS. It is reasonable to consider EMS- or dispatcher-guided administration of aspirin by bystanders despite limited direct evidence to support or refute the practice.

Clopidogrel and other platelet ADP-receptor antagonists

Clopidogrel is recommended in addition to standard care (aspirin, anticoagulants, and/or reperfusion) for patients determined to have moderate to high-risk non-ST-elevation ACS and STEMI.

Prasugrel may be administered after angiography to patients with NSTEMI presenting with stenoses amenable to PCI. ED or prehospital administration of clopidogrel should be withheld even in patients who are not at high risk for bleeding pending consideration of prasugrel administration following angiography. In patients who are not at high risk for bleeding with planned PCI and who are determined to have STEMI less than 12 h after initial symptoms, prasugrel may be substituted for clopidogrel. Prasugrel is not recommended for STEMI patients receiving fibrinolysis.

Ticagrelor (not yet approved for administration in some countries) may be given instead of clopidogrel in addition to standard care (aspirin, anticoagulants, and/or reperfusion) to patients determined to have non-ST-elevation ACS or STEMI managed with early invasive strategy by hospital personnel.

Anticoagulants

For patients with non-ST-elevation ACS managed with a planned initial conservative approach, either fondaparinux or enoxaparin are reasonable alternatives to unfractionated heparin (UFH). For patients with non-ST-elevation ACS managed with a planned invasive approach, either enoxaparin or UFH are reasonable choices. Bivalirudin may be considered as an alternative but does not appear to offer an advantage over UFH. Fondaparinux may be used in the setting of PCI but requires coadministration of UFH and does not appear to offer an advantage over UFH alone.

For patients with non-ST-elevation ACS and renal insufficiency, bivalirudin or UFH may be considered. For patients with non-ST-elevation ACS and increased bleeding risk and for whom anticoagulant therapy is not contraindicated, fondaparinux or bivalirudin are reasonable and UFH may be considered.

For patients with STEMI managed with fibrinolysis (including those in the out-of-hospital setting), it is reasonable to administer enoxaparin instead of UFH. Patients initially treated with enoxaparin should not be switched to UFH (or those on UFH should not be switched to enoxaparin) to avoid increased bleeding risk. Fondaparinux may be considered in the hospital for patients treated specifically with nonfibrin-specific thrombolytics (i.e., streptokinase), provided the creatinine level is $<3\ mg\ dL^{-1}$.

For patients with STEMI undergoing contemporary PCI, enoxaparin may be considered a safe and effective alternative to UFH. To avoid increased risk of bleeding, patients initially treated with enoxaparin should not be switched to UFH (and those treated with UFH should not be switched to enoxaparin). In comparison with UFH, fondaparinux reduces risk of bleeding in STEMI patients undergoing PCI. There is an increased risk of catheter thrombi with fondaparinux alone. Bivalirudin may be superior to UFH plus glycoprotein IIb/IIIa blockers with respect to bleeding and mortality in STEMI patients undergoing PCI. An increased rate of stent thromboses has been observed with bivalirudin in the first 24 h after PCI.

Glycoprotein IIb/IIIa Inhibitors

There were insufficient data to support the routine use of glycoprotein IIb/IIIa inhibitors in patients with suspected STEMI or non-ST-elevation ACS in the out-of-hospital or ED settings. For selected high-risk patients with non-ST-elevation ACS, administration of abciximab, eptifibatide, or tirofiban may be acceptable, provided PCI is planned. There is an increased risk of bleeding with routine administration of glycoprotein IIb/IIIa blockers when used with heparins. Alternatives for anticoagulation and antiplatelet treatment might be considered instead.

Reperfusion strategies

In the majority of patients STEMI occurs as the result of a recent acute occlusion of a major epicardial coronary artery due to the disruption of atherosclerotic plaque and thrombus formation. Strategies aimed at restoring myocardial perfusion are an important part of the management of these patients. Restoring coronary blood flow and myocardial perfusion either by pharmacological (fibrinolytics) or mechanical therapy (PCI) has been demonstrated to improve outcomes in patients presenting within 12 h of symptom onset and later in other patient groups, such as those with cardiogenic shock. There is evidence that prehospital fibrinolysis reduces delay to treatment, especially in rural areas with long transit times. In these settings prehospital fibrinolysis is a reasonable treatment strategy.

Prehospital fibrinolysis

In patients with STEMI diagnosed in the out-of-hospital setting, reperfusion may be achieved by healthcare provider administration of fibrinolytics in the field. Alternatively fibrinolytic therapy may be administered on arrival at the hospital. If fibrinolysis is chosen as the reperfusion strategy, it should be started as soon as possible, ideally in the out-of-hospital setting, and should be administered by paramedics, nurses, or doctors under well-established protocols, competency training programs, and programs of continuous quality improvement with medical oversight.

Choice of in-hospital reperfusion strategy

Programs should be implemented to reduce the time to PCI. Shorter intervals to reperfusion increase myocardial salvage, whereas delays to reperfusion increase morbidity and mortality. The precise threshold of PPCI-related delays that should trigger the decision for fibrinolysis has not been definitively established, but time to PCI should be as short as possible. Individual Councils will determine the acceptable limit or target interval from first medical contact to PCI in light of likely patient factors and available

healthcare system resources, and the reader is referred to those Council-specific guidelines for more detailed information.

For patients presenting within 12 h of symptom onset and with ECG findings consistent with STEMI, reperfusion should be initiated as soon as possible, independently of the method chosen. The benefit of mechanical intervention over fibrinolysis varies considerably depending on the patient's condition and the duration of PPCI-related delays.

The precise threshold of PPCI-related delays that should trigger the decision for fibrinolyisis has not been definitively established, and individual Councils will determine the acceptable limits from first medical contact to PCI in light of likely patient factors and local healthcare system variables and resources and the reader is referred to those Council-specific guidelines. For those patients with a contraindication to fibrinolysis, PCI should still be pursued despite the delay, rather than offering no reperfusion therapy.

For those STEMI patients presenting in shock, PCI (or coronary artery bypass surgery) is the preferred reperfusion treatment. Fibrinolysis should only be considered if there is a substantial delay to PCI.

Combined PCI and fibrinolysis

The routine use of fibrinolysis-facilitated PPCI, compared with PPCI alone, is not recommended in patients with suspected STEMI. It is reasonable to perform angiography and possible PCI in patients with failed fibrinolysis according to clinical signs or insufficient ST-segment resolution or both.

Additional medical therapy

Several additional medical therapies have been proposed for ACS patients with the goal of reducing complications from myocardial ischaemia, decreasing major adverse cardiac events, and ultimately increasing long-term survival. Therapeutic options include antiarrhythmics, β-blockers, angiotensin-converting enzyme (ACE) inhibitors, and HMG-CoA reductase inhibitors (statins). Most data regarding the usefulness of these therapies have not been derived from patients in the out-of-hospital or ED settings. Traditional preventive interventions usually start with the first admission with a confirmed diagnosis of ACS. The current evidence indicates that none play a significant role in out-of-hospital and ED management of ACS.

Healthcare system interventions for ACS

Several systems-related strategies have been developed to improve quality of care for patients with ACS and to reduce reperfusion delay for patients with STEMI in the out-of-hospital setting and in the ED. These strategies focus on the use of prehospital 12-lead ECG and time-saving strategies to facilitate early diagnosis and rapid treatment for patients with STEMI.

Out-of-hospital 12-lead ECGs performed by out-of-hospital personnel facilitate earlier diagnosis of STEMI and provide the opportunity for rapid out-of-hospital reperfusion or rapid triage of patients to institutions able to provide such reperfusion. EMS personnel should acquire a 12-lead out-of-hospital ECG for all patients exhibiting signs and symptoms of ACS and provide advance notification to receiving institutions for patients diagnosed with STEMI. Advance notification may be achieved by direct transmission of the ECG or interpretation of the ECG by out-of-hospital personnel and advance notification. Advance notification should prompt preparations at the receiving institution to provide rapid reperfusion for the arriving STEMI patient.

Hospitals should implement out-of-hospital activation of the catheterisation laboratory for patients suspected of having STEMI who arrive by EMS transport, and first-physician contact activation of the catheterisation laboratory for suspected STEMI patients who arrive by other means. Hospitals may implement additional institution-specific techniques to improve systems of care for STEMI; however, there is little evidence to support widespread implementation. These techniques include arranging single-call activation of the catheterisation laboratory, requiring that the catheterisation laboratory be ready in 20 min, having the interventional cardiologist immediately available at the hospital, providing real-time data feedback, fostering senior management commitment, and encouraging a team-based approach.

It is reasonable to consider direct transport to PCI-capable facilities for PPCI for patients diagnosed with STEMI by EMS in the out-of-hospital setting, bypassing closer EDs as necessary, in systems where time intervals between first medical contact and balloon time are brief. In patients presenting early after onset of chest pain (<2 h) and in certain clinical subsets (age <65 years, anterior STEMI), out-of-hospital fibrinolysis may offer similar outcomes compared with PPCI.

In patients with STEMI or new left bundle branch block (LBBB) on ECG following ROSC after OHCA, immediate angiography and PCI should be considered. It is reasonable to perform immediate angiography and PCI in selected patients despite the absence of ST-segment elevation on the ECG or prior clinical findings such as chest pain. Clinical findings of coma before PCI are common in patients with OHCA and are not a contraindication to consideration for immediate angiography and PCI. It is reasonable to include cardiac catheterisation in standardised post-cardiac arrest protocols as part of an overall strategy to improve neurologically intact survival in this patient group. Therapeutic hypothermia is recommended in combination with PPCI and should be started as early as possible, preferably before initiation of PCI.

Paediatric BLS and ALS

The following is a list of changes and issues that required reemphasis in paediatric basic and advanced life support.

Systems

The use of medical emergency teams (MET) or rapid response teams (RRT) has been shown to be effective in preventing respiratory and cardiac arrests in selected paediatric inpatient settings.

Family presence during resuscitations has been shown to be beneficial for the grieving process and in general was not found to be disruptive. Thus, family presence is supported if it does not interfere with the resuscitative effort.

Assessment

Many healthcare providers find it difficult to rapidly and accurately determine the presence or absence of a pulse. On the basis of the available evidence, the task force decided to de-emphasise but not eliminate the pulse check as part of the healthcare provider assessment. Task force members recognised that healthcare providers who work in specialised settings may have enhanced skills in accurate and rapid pulse checks, although this has not been scientifically verified.

There are considerable data on the use of end-tidal CO_2 measurement, capnography, and capnometry during CPR as a measure of CPR quality and as a predictive measure of outcome. Although capnography/capnometry may reflect the quality of CPR, there is insufficient evidence of its reliability in predicting resuscitation success in infants and children.

Airway and ventilation

Opening and maintaining a patent airway and providing ventilations are fundamental elements of paediatric CPR, especially because cardiac arrest often results from, or is complicated by, asphyxia. There are no new data to change the 2005 ILCOR recommendation to use manual airway maneuver (with or without an oropharyngeal airway) and bag-mask ventilation for children who require airway control or positive-pressure ventilation for short periods in the out-of-hospital setting. When airway control or bag-mask ventilation is not effective, placement of a supraglottic airway may be helpful when performed by properly trained personnel.

Data suggest that the routine use of cricoid pressure (Sellick maneuver) when performing tracheal intubation may not protect against aspiration and may make intubation more difficult.

Routine confirmation of tracheal tube position with capnography/capnometry is recommended with the caveat that infants and children in cardiac arrest may have concentrations of exhaled CO_2 below detection limits for colorimetric devices.

After ROSC, toxic oxygen byproducts (reactive oxygen species, free radicals) are produced that may damage cell membranes, proteins, and DNA (reperfusion injury). Although there are no clinical studies in children outside the newborn period comparing different concentrations of inspired oxygen during and immediately after resuscitation, animal data from newborn resuscitation studies suggest that it is prudent to titrate inspired oxygen after return of a perfusing rhythm to prevent hyperoxaemia.

Chest compressions

Chest compression-only CPR is very attractive because it is easier to teach than conventional CPR and immediate chest compressions may be beneficial for resuscitation from sudden death due to VF/pulseless VT. Animal studies showed that conventional CPR, including ventilations and chest compressions, is best for resuscitation from asphyxial cardiac arrest. In a large study of out-of-hospital paediatric cardiac arrest,[38] children with asphyxial arrest who received chest compressions plus ventilations had a significantly better survival than paediatric cardiac arrest victims who were treated with chest compressions alone; the few children with asphyxial arrest who received compression-only CPR had no better outcome than the children who received no CPR.

To be effective, chest compressions must be deep, but it is difficult to determine the optimal depth in infants and children; should it be expressed as a fraction of the depth of the chest or an absolute measurement? How can this be made practical and teachable? After much discussion the task force decided that the best current data support a recommended compression depth of at least one third of the chest anterior–posterior dimension or approximately 4 cm (1.5 in.) in infants and 5 cm (2 in.) in children.

Compression–ventilation ratio in infants

The ILCOR Neonatal Task Force continues to recommend a compression–ventilation ratio of 3:1 for resuscitation of the newly born in the delivery room, with a pause for ventilation whether or not the infant has an advanced tracheal airway in place. The Paediatric Task Force reaffirmed its recommendation for a 15:2 ratio for 2-rescuer infant or child CPR with a pause for ventilation in patients without an advanced airway, and continuous compressions without a pause for ventilation plus a ventilation rate of about 8–10 breaths per minute for patients with an advanced airway. No previous recommendations were made for hospitalised newborns who received care in areas other than the delivery area or when arrest aetiology is primary cardiac rather than asphyxial. For example, consider the case of a 3-week-old infant who has a cardiac arrest after cardiac surgery. In the neonatal intensive care unit such an infant would be resuscitated according to the protocol for the newly born, but if the same newborn were in the paediatric intensive care unit, resuscitation would be performed according to the paediatric (infant/child) protocol. A resolution to this dilemma is suggested on the basis of the arrest aetiology and ease of training.

Vascular access and drug delivery

There is no new evidence to change the 2005 ILCOR recommendations regarding vascular access, including continued emphasis on the early use of intraosseous access and de-emphasis of the tracheal route of drug delivery. Epidemiological data, largely from the National Registry of CPR, reported an association between administration of vasopressin, calcium, or sodium bicarbonate and an increased likelihood of death following in-hospital cardiac arrest. These data, however, cannot be interpreted as establishing a cause-and-effect relationship. The association may be due to the greater likelihood of use of these drugs in children who fail to respond to standard BLS and ALS interventions. These studies and data in adult victims raise questions regarding the benefit of IV medications during resuscitation and reaffirm the emphasis on the performance of high-quality CPR.

Defibrillation

The Paediatric Task Force evaluated a number of issues related to defibrillation, including safe and effective energy dosing, stacked versus single shocks, use of AEDs in infants <1 year of age and paddle/pad type, size, and position. There were a few new human and animal studies on these topics, but the Level of Evidence was generally 3–5.

No new data are available to support a change in drug treatment of recurrent or refractory VT/VF. There were several human and animal publications on defibrillation-energy dosing for VF, but the data were contradictory, and the optimal safe and effective energy dose remains unknown. The new recommendation of an initial dose of 2–4 J kg^{-1} (in 2005, the recommended initial dose was 2 J kg^{-1}) is based on cohort studies showing low success in termination of VF in paediatric patients with 2 J kg^{-1}. However, these studies do not provide data on the success or safety of higher energy doses. The continued recommendation for a single initial shock rather than stacked shocks is extrapolated from the ever-increasing adult data that the long pauses in chest compressions that are required for stacked shocks lower resuscitation success rates, and the initial shock success rate is relatively high with biphasic defibrillation. No changes are recommended in pad/paddle size or position.

Although the safety of AEDs in infants <1 year of age is unknown, case reports have documented successful defibrillations in infants. A manual defibrillator or an AED with paediatric attenuation capabilities is preferred for use in infants and small children.

Emergency medications for arrhythmias

The literature on emergency drug treatment of arrhythmias was reviewed and the only change was the addition of procainamide as therapy for refractory supraventricular tachycardia.

Management of shock

The evidence reviewed was related to several key questions regarding the management of shock in children. There is ongoing uncertainty about the indications for using colloid versus crystalloid in resuscitation from shock. Data from a large adult trial

suggest that effectiveness of normal saline (isotonic crystalloid) is equivalent to albumin, although subgroup analysis suggested harm associated with the use of albumin in patients with traumatic brain injury. There were insufficient data to change the 2005 recommendations.

The optimal timing for tracheal intubation of children in shock remains unclear, although reports in children and adults with septic shock suggest that early intubation (before signs of respiratory failure develop) combined with a protocol-driven management approach may be beneficial. When children in septic shock were treated with a protocol that included therapy directed to normalizing central venous oxygen saturation, patient outcome appeared to improve.

Administering stress-dose corticosteroids in septic shock remains controversial, with recent trials in adults failing to show a beneficial effect.

Performing rapid sequence intubation of a child with shock can result in acute cardiovascular collapse. Etomidate typically causes less haemodynamic compromise than other induction drugs and is therefore often used in this setting. However, data suggest that the use of this drug in children and adults with septic shock is associated with increased mortality that may be secondary to the inhibitory effects of etomidate on corticosteroid synthesis.

Medications for cardiac arrest and bradycardia

The literature on medications used during cardiac arrest and bradycardia was reviewed and updated, but no new recommendations were made. It was again emphasised that calcium and sodium bicarbonate should not be routinely used in paediatric cardiac arrest (i.e., they should not be used without specific indications).

Extracorporeal cardiac life support

There is increasing evidence that extracorporeal cardiac life support (ECLS) can act as a bridge to maintain oxygenation and circulation in selected infants and children who are transplant candidates or who have a self-limited or treatable illness. ECLS can only be used if the cardiac arrest occurs in a monitored environment with protocols and personnel for its rapid initiation.

Post-cardiac arrest care

The literature on the benefit of hypothermia for patients who remain comatose after resuscitation from cardiac arrest was reviewed. There is clear benefit for adult patients who remain comatose after VF arrest, but the evidence is not as strong for infants and young children whose arrest is most commonly asphyxial.

Some patients with sudden death in whom an obvious cause of death is not found have a genetic abnormality of ionic channels, which presumably leads to fatal arrhythmia. Because this is an inherited abnormality, family members might be affected, but special tests are required for detection of this inherited genetic defect.

Special situations

New topics introduced include resuscitation of infants and children with certain congenital cardiac abnormalities, namely single ventricle following stage I procedure and following the Fontan or bidirectional Glenn procedures, as well as resuscitation of infants and children with cardiac arrest and pulmonary hypertension.

Prognosis and decision to terminate CPR

The literature on this important topic was reviewed and the task force concluded that there is insufficient evidence to allow a reliable prediction of success or failure to achieve ROSC or survival from cardiac arrest in infants and children.

Neonatal resuscitation

Since publication of the 2005 Guidelines several controversial neonatal resuscitation issues have been identified. The literature was researched and a consensus was reached on the assessment of oxygenation and role of supplementary oxygen, peripartum management of meconium, ventilation strategies, devices to confirm placement of an advanced airway (e.g., tracheal tube or LMA), medications, maintenance of body temperature, post-cardiac arrest care, and considerations for withholding and discontinuing resuscitation. Educational techniques for teaching, assessing, and maintaining resuscitation knowledge and skills and personnel needed at cesarean sections were also debated. The following are the major new recommendations:

- Progression to the next step after the initial evaluation is now directed by the simultaneous assessment of 2 vital characteristics, heart rate and respirations. The use of a third assessment—that of color is now replaced by oximetry assessment of oxyhaemoglobin saturation.
- For babies born at term, it is best to begin resuscitation with air rather than 100% oxygen.
- Administration of supplementary oxygen should be regulated by blending oxygen and air and the amount delivered to be guided by oximetry.
- The available evidence does not support or refute the routine tracheal suctioning of infants born through meconium-stained amniotic fluid, even when the infant is depressed.
- The compression–ventilation ratio should remain at 3:1 for neonates unless arrest is known to be of cardiac aetiology, in which case a higher ratio should be considered.
- Infants born at term or near term with evolving moderate to severe hypoxic-ischaemic encephalopathy should be offered therapeutic hypothermia, which should be initiated and conducted under clearly-defined protocols with treatment in neonatal intensive care facilities and the capabilities for multidisciplinary care and follow-up.
- It is appropriate to consider discontinuance of resuscitation if there has been no detectable heart rate for 10 min. The decision to continue resuscitation efforts beyond 10 min of no heart rate is often complex and may be influenced by many factors such as the presumed aetiology of the arrest, the gestation of the baby, the presence or absence of complications.
- Cord clamping should be delayed for at least 1 min in babies who do not require resuscitation. Evidence is insufficient to recommend a time for clamping for those who require resuscitation.

Education, implementation, and teams

The Education, Implementation, and Teams Task Force reviewed 5 major topics: (1) education, (2) risks and effects on the rescuer of CPR training and actual CPR performance, (3) rescuer willingness to respond, (4) implementation and teams, and (5) ethics and outcomes.

The key 2010 recommendations related to EIT include

- Efforts to implement new resuscitation guidelines are likely to be more successful if a carefully planned, multifaceted imple-

mentation strategy is used. Education, while essential, is only one element of a comprehensive implementation strategy.
- All courses should be evaluated to ensure that they reliably achieve the program objectives. Training should aim to ensure that learners acquire and retain the skills and knowledge that will enable them to act correctly in an actual cardiac arrest.
- BLS and ALS knowledge and skills can deteriorate in as few as 3–6 months after training. Frequent assessments and, when needed, refresher training is recommended to maintain resuscitation knowledge and skills.
- Short video/computer self-instruction courses, with minimal or no instructor coaching, combined with hands-on practice can be considered as an effective alternative to instructor-led BLS (CPR and AED) courses.
- Laypersons and healthcare providers should be trained to start CPR with chest compressions for adult victims of cardiac arrest. If they are trained to do so, they should also perform ventilations. Performing chest compressions alone is reasonable for trained rescuers if they are incapable of delivering airway and breathing maneuvers to cardiac arrest victims.
- AED use should not be restricted to trained personnel. Allowing the use of AEDs by persons without prior formal training can be beneficial and may be lifesaving. Because even brief training improves performance (e.g., speed of use, correct pad placement), it is recommended that training in the use of AEDs be provided.
- CPR prompt or feedback devices improve CPR skills acquisition and retention and may be considered during CPR training for laypeople and healthcare professionals. These devices may be considered for clinical use as part of an overall strategy to improve the quality of CPR.
- It is reasonable to wear personal protective equipment (e.g., gloves) when performing CPR. CPR should not be delayed or withheld if personal protective equipment is not available unless there is a clear risk to the rescuer.
- Manual chest compressions should not continue during delivery of a shock because safety has not been established.

Education

Effective and efficient resuscitation education is one of the essential elements in the translation of guidelines into clinical practice. Educational interventions need to be population-specific (e.g., lay rescuers, healthcare providers) and evaluated to ensure that they achieve the desired educational outcomes—not just at the end of the course but also during actual resuscitation events. Retention of knowledge and skills should be confirmed through assessment rather than assumption that they persist for preestablished time intervals.

Populations

This section includes who should be trained and how they should prepare for training.

There is insufficient evidence to support or refute the use of training interventions that focus on high-risk populations. Training with social support reduces anxiety in patients and family members, improves emotional adjustment, and increases feelings of empowerment.

ALS courses should incorporate precourse preparation including, but not limited to, use of computer-assisted learning tutorials, written self-instruction materials, video-based learning, textbook reading, and pretests. Any method of precourse preparation aimed at improving knowledge and skills or reducing instructor-to-learner face-to-face time should be formally assessed to ensure equivalent or improved learning outcomes compared with standard instructor-led courses.

Instructional methods

There are multiple methods for delivering course content. This section examines specific instructional methods and strategies that may have an impact on course outcomes. Short video/computer self-instruction (with minimal or no instructor coaching) that includes synchronous hands-on practice in BLS can be considered as an effective alternative to instructor-led courses.

AED use should not be restricted to trained personnel. Allowing the use of AEDs by persons without prior formal training can be beneficial and may be lifesaving. Because even brief training improves performance (e.g., speed of use, correct pad placement), it is recommended that training in the use of AEDs be provided. Laypersons can serve as AED instructors. Short video/computer self-instruction (with minimal or no instructor coaching) that includes synchronous hands-on practice in AED use may be considered as an effective alternative to instructor-led AED courses.

CPR prompt/feedback devices may be considered during CPR training for laypersons and healthcare providers. CPR prompt/feedback devices may be considered for clinical use as part of an overall strategy to improve the quality of CPR. Instructors and rescuers should be made aware that a compressible support surface (e.g., mattress) may cause a feedback device to overestimate depth of compression.

Specific teamwork training, including leadership skills, should be included in ALS courses. There is insufficient evidence to recommend any specific training intervention, compared with traditional lecture/practice sessions, to improve learning, retention, and use of ALS skills.

There is insufficient evidence to recommend teaching a specific technique to optimise complete chest recoil during actual CPR.

There is insufficient evidence to support or refute the use of more realistic techniques (e.g., high-fidelity manikins, in situ training) to improve outcomes (e.g., skills performance on a manikin, skills performance in a real arrest, willingness to perform) when compared with standard training (e.g., low-fidelity manikins, education center) in BLS and ALS courses.

Course format and duration

Resuscitation training courses vary widely in their duration and delivery of content. It is reasonable to consider shortening the duration of traditional instructor-led BLS courses. Brief reassessment (e.g., at 6 months) should be considered to improve skills and retention. The optimal duration of an instructor-led BLS course has not been determined. New course formats should be assessed to ensure that they achieve their objectives. There is insufficient evidence to support or refute alternative ALS course scheduling formats compared with the traditional 2-day provider course format.

Retraining intervals

It is recognised that knowledge and skills retention decline within weeks after initial resuscitation training. Refresher training is invariably required to maintain knowledge and skills; however, the optimal frequency for refresher training is unclear. For BLS providers (laypersons and healthcare providers), skills assessment and, if required, a skills refresher should be undertaken more often than the current commonly recommended training interval of 12–24 months. For ALS providers, there should be more frequent assessment of skills performance or refresher training or both than is currently recommended in established ALS programs. There is insufficient evidence to recommend an optimal interval and form of assessment or refresher training.

Assessment

A written test in an ALS course should not be used as a substitute for demonstration of clinical skills performance. Summative

assessment at the end of ALS training should be considered as a strategy to improve learning outcomes. There is insufficient evidence to recommend an optimal method of assessment during life support training.

Risks and effects on the rescuer of CPR training and actual CPR performance

The safety of rescuers is essential during training and actual CPR performance.

Physical effects

CPR training and actual performance is safe in most circumstances. Learners and rescuers should consider personal and environmental risks before starting CPR. Learners undertaking CPR training should be advised of the nature and extent of the physical activity required during the training program. Learners who develop significant symptoms (e.g., chest pain, severe shortness of breath) during CPR should be advised to stop. Rescuers who develop significant symptoms during actual CPR should consider stopping CPR.

Rescuer fatigue

When performing chest compressions, if feasible, it is reasonable to consider changing rescuers after about 2 min to prevent rescuer fatigue (demonstrated by deterioration in chest compression quality, in particular, depth of compressions). The change of rescuers performing chest compressions should be done with minimal interruption in compressions.

Risks during defibrillation attempts

The risks associated with defibrillation are less than previously thought. There is insufficient evidence that it is safe for the rescuer to continue manual chest compressions during shock delivery for VF (defibrillation). It is reasonable for rescuers to wear gloves when performing CPR and attempting defibrillation (manual or AED), but resuscitation should not be delayed or withheld if gloves are not available. There is insufficient evidence to make a recommendation regarding the safety of physical contact with a patient during ICD discharge. There is insufficient evidence to make a recommendation about the best method for a rescuer to avoid receiving shocks from an ICD discharge during CPR. Although there are no reports of harm to rescuers, there is insufficient evidence to make a recommendation regarding the safety of defibrillation in wet environments.

Psychological effects

There are few reports of psychological harm to rescuers after they are involved in a resuscitation attempt. There is insufficient evidence to support or refute any recommendation on minimising the incidence of psychological harm to rescuers.

Disease transmission

The risk of disease transmission during training and actual CPR performance is very low. Rescuers should take appropriate safety precautions, especially if a victim is known to have a serious infection (e.g., human immunodeficiency virus [HIV], tuberculosis, hepatitis B virus, or severe acute respiratory syndrome [SARS]).

Rescuer willingness to respond

Increasing the willingness of individuals to respond to a cardiac arrest with early recognition, calling for help, and starting CPR is essential to improve survival rates.

To increase willingness to perform CPR, laypersons should receive training in CPR that includes recognition of gasping or abnormal breathing as a sign of adult cardiac arrest when other signs of life are absent. Laypersons should be trained to start resuscitation with chest compressions in adult and paediatric victims. If unwilling or unable to perform ventilations, rescuers should be instructed to continue compression-only CPR. EMS dispatchers should provide chest compression-only CPR instructions to callers who report adult cardiac arrest and these instructions should include recognition of gasping and abnormal breathing (see Part 5: Adult Basic Life Support, for further information).

Implementation and teams

The best scientific evidence for resuscitation interventions will have little impact on patient outcomes if it is not effectively translated into clinical practice. Successful implementation is dependent on effective educational strategies to ensure that resuscitation providers have the necessary knowledge and skills in combination with the necessary infrastructure and resources. Education itself is only one strategy for implementing changes.

Implementation strategies

Institutions or communities planning to implement complex guidelines, such as therapeutic hypothermia, should consider using a comprehensive, multifaceted approach, including clinical champions; a consensus-building process; multidisciplinary involvement; written protocols; detailed process description; practical logistic support; multimodality, multilevel education; and rapid cycle improvement methods.

Individual and team factors

Individual and team factors affect performance during resuscitation attempts. It is reasonable to use cognitive aids (e.g., checklists) during resuscitation, provided that their use does not delay the start of resuscitative efforts. Aids should be validated using simulation or patient trials both before and after implementation to guide rapid cycle improvement. It is reasonable to recommend the use of briefings and debriefings during both learning and actual clinical activities.

There is insufficient evidence to recommend for or against physicians versus nonphysician providers of ALS during prehospital CPR.

System factors

Implementation of AED programs in public settings should be based on the characteristics of published reports of successful programs in similar settings. Home AED use for high-risk individuals who do not have an ICD has not been shown to change overall survival rates.

Because population (e.g., rates of witnessed arrest) and program (e.g., response time) characteristics affect survival, when implementing an AED program, community and program leaders should consider factors such as location, development of a team with responsibility for monitoring and maintaining the devices, training and retraining programs for those who are likely to use the AED, coordination with the local EMS agency, and identification of a group of paid or volunteer individuals who are committed to providing CPR and using the AED for victims of arrest.

Although extrapolation from randomised and observational studies of systems of care for other acute time-sensitive conditions (trauma, STEMI, stroke) suggests that specialised cardiac arrest centers and systems of care may be effective, there is insufficient direct evidence to recommend for or against their use. There is insufficient evidence to make recommendations supporting or refuting the effectiveness of specific performance measurement interventions to improve processes of care and clinical outcomes in resuscitation systems.

There is insufficient evidence to recommend for or against paediatric or adult basic or advanced level life support training programs in low-income countries. However, there is evidence that emergency medical training programs in neonatal and trauma resuscitation should be considered in these countries. When delivering programs in low-income countries, consideration should be given to local adaptation of training, use of existing and sustainable resources for both care and training, and development of a dedicated local infrastructure.

Recognition and prevention

Patients who have cardiac arrest often have unrecognised or untreated warning signs. This section describes strategies to predict, recognise, and prevent cardiorespiratory arrest, including the role of education.

Children and young adults presenting with characteristic symptoms of arrhythmic syncope should be assessed by a cardiology specialist. The assessment should include an ECG and in most cases an echocardiogram and exercise test. Characteristics of arrhythmic syncope include syncope in the supine position, during or after exercise, with no or only brief prodromal symptoms, repetitive episodes, or in persons with a family history of sudden death. In addition, nonpleuritic chest pain, palpitations associated with syncope, seizures (when resistant to treatment, occurring at night, or precipitated by exercise, syncope, or loud noise), and drowning by a competent swimmer should raise suspicion of increased risk. Systematic evaluation in a clinic specialising in the care of those at risk for sudden cardiac death is recommended in family members of young victims of sudden cardiac death or those with a known cardiac disorder resulting in an increased risk of sudden cardiac death.

In adults admitted to the hospital, there is insufficient evidence to support or refute the use of early warning systems/RRT systems or MET systems (compared with no such systems) to reduce cardiac and respiratory arrests and hospital mortality. However, it is reasonable for hospitals to provide a system of care that includes (1) staff education about the signs of patient deterioration, (2) appropriate and regular monitoring of the patient's vital signs, (3) clear guidance (e.g., via calling criteria or early warning scores) to assist staff in early detection of patient deterioration, (4) a clear, uniform system to call for assistance, and (5) a clinical response to calls for assistance. There is insufficient evidence to identify the best methods for delivery of these components and, based on current evidence, this should be based on local circumstances.

Hospitals should use a system validated for their specific patient population to identify individuals at increased risk of serious clinical deterioration, *respiratory arrest*, or cardiac arrest, both on admission and during hospital stay. There is insufficient evidence to identify specific educational strategies that improve outcomes (e.g., early recognition and rescue of the deteriorating patient at risk of cardiac/respiratory arrest). Educational efforts have a positive impact on knowledge, skills, and attitudes/confidence and increase the frequency of activation of a response and should therefore be considered.

Ethics and outcomes

The decision to start, continue, and terminate resuscitative efforts is based on the balance of the risks, benefits, and burdens these interventions place on patients, family members, and healthcare providers. There are circumstances where resuscitation is inappropriate and should not be provided. These include when there is clear evidence that to start resuscitation would be futile or against the expressed wishes of the patient. Systems should be established to communicate these prospective decisions, and simple algorithms should be developed to assist rescuers in limiting the burden of unnecessary, potentially painful treatments.

Decisions before cardiac arrest

Standardised orders for limitations on life-sustaining treatments (e.g., do not attempt resuscitation [DNAR], physician orders for life-sustaining treatment [POLST]) should be considered to decrease the incidence of futile resuscitation attempts and to ensure that the adult patient's wishes are honored. Instructions should be specific, detailed, transferable across healthcare settings, and easily understood. Processes, protocols, and systems should be developed that fit within local cultural norms and legal limitations to allow providers to honor patient wishes regarding resuscitative efforts.

Termination-of-resuscitation rules

Termination-of-resuscitation rules such as the "BLS termination of resuscitation rule" have been prospectively validated in the out-of-hospital setting for use by paramedics and are recommended to guide termination of out-of-hospital CPR in adults. Other rules for various provider levels, including in-hospital providers, may be helpful to reduce variability in decision making; however, rules should be prospectively validated before implementation.

Quality of life

Part of the decision-making process in deciding for or against the decision to initiate resuscitation is the likelihood of success of the resuscitation attempt and the quality of life that can be expected after discharge from the hospital.

Resuscitation after cardiac arrest produces a good quality of life in most survivors. There is little evidence to suggest that resuscitation leads to a large number of survivors with an unacceptable quality of life. Survivors may experience postarrest problems, including anxiety, depression, posttraumatic stress, and difficulties with cognitive function. Clinicians should be aware of these potential problems, screen for them, and, if found, treat them. Interventional resuscitation studies should be encouraged to include a follow-up evaluation (ideally at least 6 months after the event) that assesses general health-related quality of life with a validated instrument, affective disorder (anxiety and depression), posttraumatic stress disorder, and cognitive function.

Future directions

The science of resuscitation is evolving rapidly. It will not be in the best interests of patients if we wait 5 or more years to inform healthcare professionals of therapeutic advances in this field. ILCOR members will continue to review new science and, when necessary, publish interim advisory statements to update treatment guidelines so that resuscitation practitioners may provide state-of-the-art treatment. Existing gaps in knowledge will be closed only by continuing high-quality research into all facets of CPR.

CoSTR Part 1: Executive Summary Writing Group disclosures

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; University and medical center; Professor; AHA ECC Product Development Senior Science Editor; I receive significant AHA compensation to co-edit, the publication of the 2010 CoSTR and the 2010 AHA Guidelines for CPR and ECC	None	None	None	None	None	None
Jerry P. Nolan	Royal United Hospital NHS Trust; National Health Service Hospital; Consultant in Anaesthesia and Intensive Care	None	None	None	None	None	None
John E. Billi	University of Michigan: Medical School – Professor	None	None	None	None	None	None
Bernd W. Boettiger	Uniklinik Köln – MD, DEAA	None	None	None	None	None	None
Leo Bossaert	University of Antwerp; Professor	None	None	None	None	None	None
Allan R. de Caen	Self-employed Paediatric Intensivist	None	None	None	None	None	[*] Medical expert for Canadian Medical Protective Association
Charles D. Deakin	South Hampton University Hospital	None	None	None	None	None	None
Saul Drajer	Clinica de la Esperanza: General Director of a 130 bed general hospital (Clinica de la Esperanza) located in Buenos Aires, Argentina – General Director	None	None	None	None	None	None
Brian Eigel	American Heart Association Director of Science, ECC Programs	None	None	None	None	None	None
Robert W. Hickey	University of Pittsburgh – Associate Professor	[†] Salary support from NIH for grant examining cyclopentenone prostaglandin effects in ischaemic brain injury	None	None	None	None	[*] 1–2X/year medical malpractice expert

Ian Jacobs	University of Western Australia: Discipline of Emergency Medicine Teaching/Research academic – Professor; American Heart Association – Evaluation of evidence worksheets for C2010 – Work Sheet Expert	†Chief investigator on numerous grants awarded by: (a) National Health and Medical Research Council (b) The Department of Health – Western Australia (c) The National Heart Foundation of Australia These funds are awarded to the University of Western Australia and none are used to provide any direct or indirect salary or other financial support	†Funds are received into 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 CA 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
Monica E. Kleinman	Children's Hospital Anesthesia Foundation, Sr Associate in Critical Care Medicine	None	None	None	None	None	None
Walter Kloeck	Academy of Advanced Life Support: Basic and advanced life support training – Medical Director	None	None	None	None	None	None
Rudolph W. Koster	Academic Medical Center – full-time employee-staff cardiologist	None	†Jolife covers cost of CT scans, autopsy and a 50 Euro per patient contribution to the institution (times 120 patients) †Zoll covers cost of CT scans, autopsy and a 50 Euro per patient contribution to the institution (times 120 patients) *Jolife: Lucas chest compression device on loan to institution for research purposes *Zoll: Autopulse chest compression device on loan to institution for research purposes *Phillips: Chest compression feedback device on loan to institution for research purposes	None	None	None	None
Swee Han Lim	Singapore General Hospital Tertiary Public Hospital; Sr Consultant ED	None	None	None	None	None	None
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CoSTR Part 1 (*Continued*)

Writing group member	Employment	Research grant	Other research support	Speakers' bureau/Honoraria	Ownership interest	Consultant/ Advisory Board	Other
William H. Montgomery	Self-employed anesthesiology: Practice of anesthesiology; Self-employed Consultant – Coordinating and planning the AHA C2010 Conference	None	None	None	None	None	None
Peter T. Morley	Royal Melbourne Hospital: Director of Medical Education; University of Melbourne: Clinical Dean, Royal Melbourne Hospital; AHA – Evidence Evaluation Expert	None	None	None	None	None	None
Laurie J. Morrison	St. Michaels; clinician scientist	*Laerdal Foundation Centre Grant – infrastructure support without salary support	None	None	None	None	None
Vinay M. Nadkarni	University of Pennsylvania School of Medicine, Children's Hospital of Philadelphia – Non-profit, Academic, University Hospital – Attending Physician, Anesthesia, Critical Care and Paediatrics	†NIH RO1: Co-Investigator, Therapeutic hypothermia after paediatric cardiac arrest †AHRQ: Agency for Healthcare Research and Quality: PI, Safety of Tracheal Intubation in the Paediatric ICU †Laerdal Foundation for Acute Care Medicine, Center of Excellence Grant, PI; *NHTSA: Co-I, Characteristics of chest compression in children *NIH RO1: Co-I, Neuroprotection during Deep Hypothermic Cardiac Arrest and Cardiopulmonary Bypass	None	None	None	None	None
Robert E. O'Connor	University of Virginia Health System – Professor and Chair of Emergency Medicine	None	None	None	None	None	None
Kazuo Okada	JRC – Administration of JRC President	None	None	None	None	None	None
Jeffrey M. Perlman	Weill Cornell: Professor of Paediatrics	†NIH – Improving antimicrobial prescribing practices in the NICU	None	None	None	None	None
Michael R. Sayre	The Ohio State University – Associate Professor	None	None	None	None	None	None
Michael Shuster	Self-employed – Emergency Physician	None	None	None	None	None	None
Jasmeet Soar	North Bristol NHS Trust – Government Hospital in UK – Consultant in Anaesthetics & Intensive Care Medicine	None	None	None	None	None	None

Kjetil Sunde	Oslo University Hospital Ulleval	None	None	None	None	None	None
Andrew H. Travers	Emergency Health Services, NS Department of Health, Nova Scotia Provincial Medical Director	†Lead Principal Investigator for the Public Access Defibrillation Trial for Edmonton, Alberta, Canada and received grant funding from NHLBI through contracts at the University of Washington which acted as the CRC; Lead Principal Investigator for the Public Access Defibrillation Trial for Edmonton, Alberta, Canada and received grant funding from †NHLBI through contracts at the University of Washington which acted as the CRC	None	None	None	None	None
Jonathan Wyllie	South Tees Foundation NHS Trust Health Service Provider NHS UK Consultant Neonatologist and Clinical Director of Neonatology	None	None	*Spoke for "Trouble Up North" sponsored by Chiesi Other invited lectures for no cost *Will receive small honorarium for speaking at the Middlesbrough Neonatal meeting Honorarium as above from Chiesi	None	*Consultant Advisory Board European Resuscitation Council Board Member and ICC co-chair. Voluntary expenses only Resuscitation Council (UK) *Executive member and Chair of Newborn Life Support Working Group. Voluntary expenses only *HEMS Clinical Governance Group. Voluntary expenses only *North east Ambulance Clinical Governance Group. Voluntary expenses only	*Expert Witness: Occasional case. Nothing recent but one pending report in the UK now
David Zideman	Imperial College NHS Trust: United Kingdom Healthcare Provider – Consultant Anaesthetist; London Organising Committee of the Olympic Games – Lead Clinician for Emergency Medical Services	None	None	None	None	None	*Expert witness for Her Majesty's Coroner for Surrey – expert advice on cardiac arrests under general anesthesia – fee for providing written testimony and personal attendance at court – fee less than 1500 US dollars

* Modest.

† Significant.

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.

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