



European Resuscitation Council Guidelines for Resuscitation: 2017 update



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Introduction

As a founding member of the International Liaison Committee on Resuscitation (ILCOR), the European Resuscitation Council (ERC) remains wholeheartedly committed to supporting ILCOR's mission, vision and values [1]. One of the main functions of ILCOR over the last 25 years has been to review published research evidence periodically to produce an international Consensus on Science with Treatment Recommendations (CoSTR). Since 2000, ILCOR has provided an updated CoSTR every 5 years [2–5] which the ERC has subsequently incorporated into its guidelines [6–8]. In recent years, the scale and pace of new clinical trials and observational studies in resuscitation science has grown exponentially. This prompted ILCOR to review its approach to evidence synthesis and to transition from a 5-yearly CoSTR to more regular updates, driven by the publication of new science rather than arbitrary time point anchors.

The first output of this new process was published in November 2017 and focused on the relationship between chest compression and ventilation during CPR [9].

The ERC welcomes the new, more responsive approach to evidence synthesis developed by ILCOR. In embracing this approach, the ERC has considered how best to integrate any changes prompted by ILCOR into our guidelines. The ERC recognises the substantial time, effort and resources required to implement changes to resuscitation guidelines [10]. The ERC is also cognisant of the confusion that could be caused by frequent changes to guidelines, which could impair technical and non-technical skill performance and adversely impact patient outcomes. Nevertheless, if new science emerges which presents compelling evidence of benefits or harms, prompt action must be taken to translate it immediately into clinical practice.

In an attempt to balance these conflicting priorities, the ERC has decided to maintain a 5-yearly cycle for routine updates to its guidelines and course materials. Each new CoSTR published by ILCOR will be reviewed by the ERC Guidelines and Education Development Committees that will assess the likely impact of the new CoSTR on our guidelines and education programmes. These committees will consider the potential impact of implementing any new CoSTR (lives saved, improved neurological outcome, reduced

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costs) against the challenges (cost, logistical consequences, dissemination and communication) of change. CoSTRs which present compelling new data which challenge the ERC's current guidelines or educational strategy will be identified for high priority implementation; guidelines and course materials will then be updated outside the 5-year review period. By contrast, new information which will lead to less critical, incremental changes to our guidelines will be identified for lower priority implementation. Such changes will be introduced during the routine, 5-yearly update of guidelines.

ILCOR CoSTR 2017

The ILCOR CoSTR 2017 addressed different approaches to chest compression and ventilation (compression-only CPR, compressions with asynchronous ventilations (ventilations delivered without pausing chest compressions), compressions with passive oxygen inflation, and various compression to ventilation ratios (5:1, 15:2, 30:2, 50:2) in a variety of contexts. The systematic review and meta-analysis identified 28 unique studies (one cluster randomised trial, three individual patient randomised studies, 24 cohort studies) [11]. Evidence was synthesised in six domains – Dispatcher-assisted CPR [12], Bystander delivered CPR [13], Emergency Medical Services (EMS) delivered CPR [14], compression to ventilation ratio [14], in-hospital resuscitation [15], and paediatric resuscitation [16]. The overall quality of evidence ranged from very low to high which supported 4 strong and 10 weak treatment recommendations. The ERC considered each of the new CoSTRs in the context of contemporary resuscitation practice in Europe. Table 1 presents a summary of the ERC guidelines, relevant changes and the timeframe for implementation. More detailed information is presented in the sub-sections below. No new evidence for neonatal resuscitation was identified so these guidelines remain unchanged. Adult, paediatric and neonatal algorithms are presented in Figs. 1 and 2.

Dispatcher assisted CPR [13]

Recent evidence reinforces the importance of bystander CPR to improve survival from cardiac arrest [17–21]. The ERC recognises the critical role that the EMS dispatcher and dispatch protocols play in supporting bystander initiated CPR [22–26].

ERC 2017 guidelines

The key recommendations from the ERC remain that “dispatchers should provide telephone-CPR instructions in all cases of suspected cardiac arrest unless a trained provider is already delivering CPR. Where instructions are required for an adult victim, dispatchers should provide compression-only CPR instructions. If the victim is a child, dispatchers should instruct callers to provide both ventilations and chest compressions. Dispatchers should therefore be trained to provide instructions for both techniques [27].

ILCOR CoSTR in context of ERC guidelines

The ERC Guidelines are concordant with the ILCOR treatment recommendation that “dispatchers provide instructions to perform continuous chest compressions (i.e. compression-only CPR) to callers for adults with suspected out-of-hospital cardiac arrest.” The ERC notes the gaps in knowledge identified by ILCOR and highlights the need for further research particularly in relation to improving identification of cardiac arrest [28], when to include ventilations as part of the dispatcher instructor sequence, and the role of enhanced citizen/first responder schemes [29–34].

Bystander CPR (adults) [13]

Several public health initiatives have successfully increased bystander CPR rates and cardiac arrest survival, [19,35–39] emphasising the importance of engaging lay rescuers in efforts to improve outcomes for patients who suffer sudden out-of-hospital cardiac arrest. One of the key questions related to bystander CPR is whether lay rescuers should be trained to provide compression-only CPR or compressions and ventilations. This question was addressed in one of the observational studies assessing the effects of nationwide dissemination of compression-only CPR for lay rescuers [36], and consequently added to ILCOR's most recent evidence review. While crude analysis of patient outcomes between the two groups favoured compressions and ventilations (30:2), significant differences in demographic and prognostic factors between the two groups complicate the interpretation of data.

ERC 2017 guidelines

The ERC recommends that the adult BLS sequence remains unchanged and continues to endorse ILCOR's recommendations that “all CPR providers should perform chest compressions for all patients in cardiac arrest. CPR providers trained and able to perform rescue breaths should perform chest compressions and rescue breaths” [27].

ILCOR CoSTR in context of ERC guidelines

The ERC guidance is concordant with the ILCOR treatment recommendation that “chest compressions should be performed for all patients in cardiac arrest” as well as ILCOR's suggestion that “those who are trained, able and willing to give rescue breaths do so for all adult patients in cardiac arrest”. The crude analysis of unadjusted data from the Iwami study [36], published after the ERC 2015 guidelines were finalised, supports the ERC position that combined compressions and ventilations may be superior to compression-only CPR”. Although there is significant uncertainty about the effect in that study, it does not contradict the current ERC recommendation to perform both compression and ventilations as that may provide additional benefit for children and those who sustain an asphyxial cardiac arrest [40–43], or where the EMS response interval is prolonged [44].

EMS-delivered CPR (adults) [14]

A recent large randomised controlled trial compared positive pressure ventilations delivered by EMS personnel with a bag-mask without pausing chest compressions (asynchronous ventilation) to a control group receiving conventional CPR (30:2) before placement of an advanced airway [45]. There was no demonstrable benefit for survival to discharge among patients who were randomised to continuous compressions with asynchronous ventilation (difference, –0.7%; 95% confidence interval [CI], –1.5 to 0.1; P = 0.07) [45]. The publication of this trial prompted ILCOR to update the systematic review and evidence evaluation of EMS-delivered CPR.

ERC 2017 guidelines

The ERC's key recommendation remains that EMS providers perform CPR with 30 compressions to 2 ventilations before placement of an advanced airway. Once a tracheal tube or supraglottic device has been inserted, ventilate the lungs at 10 breaths min⁻¹ and compress the chest at a rate of 100–120 per minute.

The ERC does not recommend “minimally interrupted cardiac resuscitation” (continuous chest compressions with passive

Table 1
Summary of ILCOR CoSTR and ERC Guidelines 2017. The Table indicates changes to ERC Guidelines and Timescale for implementation. High priority implementation will lead to active updates to course materials and dissemination of important changes. Routine implementation will be updated during the training material updates in 2020.

| Topic | ILCOR CoSTR | ERC Guideline | ERC Guideline change | Timescale for implementation |
|----------------------------------|--|---|--|------------------------------|
| Dispatcher assisted CPR | We recommend that dispatchers provide chest compression–only CPR instructions to callers for adults with suspected out-of-hospital cardiac arrest (OHCA) (strong recommendation, low-quality evidence). | Dispatchers should provide telephone-CPR instructions in all cases of suspected cardiac arrest unless a trained provider is already delivering CPR. Where instructions are required for an adult victim, dispatchers should provide chest-compression-only CPR instructions. If the victim is a child, dispatchers should instruct callers to provide both ventilations and chest compressions. Dispatchers should therefore be trained to provide instructions for both techniques | No change | N/A |
| Bystander CPR | We recommend that bystanders perform chest compressions for all patients in cardiac arrest (strong recommendation but based on very low-quality evidence). We suggest that bystanders who are trained, able, and willing to give rescue breaths and chest compressions do so for all adult patients in cardiac arrest (weak recommendation, very-low-quality evidence). | All CPR providers should perform chest compressions for all patients in cardiac arrest. CPR providers trained and able to perform rescue breaths should perform chest compressions and rescue breaths | No change | N/A |
| EMS CPR | We recommend that EMS providers perform CPR with 30 compressions to 2 ventilations or continuous chest compressions with PPV delivered without pausing chest compressions until a tracheal tube or supraglottic device has been placed (strong recommendation, high quality evidence). We suggest that when EMS systems have adopted minimally interrupted cardiac resuscitation, this strategy is a reasonable alternative to conventional CPR for witnessed shockable OHCA (weak recommendation, very-low-quality evidence). | EMS providers should perform CPR with 30 compressions to 2 ventilations before placement of an advanced airway. Once a tracheal tube or supraglottic device has been inserted, ventilate the lungs at 10 breaths min ⁻¹ . The ERC does not recommend minimally interrupted cardiac resuscitation (continuous chest compressions with passive oxygenation typically with an oropharyngeal airway and simple oxygen mask passive oxygenation during CPR). | No change | N/A |
| Compression to ventilation ratio | We suggest a CV ratio of 30:2 compared with any other CV ratio in patients with cardiac arrest (weak recommendation, very-low-quality evidence). | The ERC recommends a compression to ventilation ratio of 30:2. | No change | N/A |
| In-hospital CPR | Whenever tracheal intubation or a supraglottic airway is achieved during in-hospital CPR, we suggest that providers perform continuous compressions with PPV delivered without pausing chest compressions (weak recommendation, very-low-quality evidence). | Start CPR by giving 30 chest compressions followed by 2 ventilations. Once the patient's trachea has been intubated or a supraglottic airway (SGA) has been inserted, continue uninterrupted chest compressions (except for defibrillation or pulse checks when indicated) at a rate of 100–120 min ⁻¹ and ventilate the lungs at approximately 10 breaths min ⁻¹ . | No change | N/A |
| Paediatric CPR | We suggest that bystanders provide CPR with ventilation for infants and children <18 years of age with OHCA (weak recommendation, very-low-quality evidence). We continue to recommend that if bystanders cannot provide rescue breaths as part of CPR for infants and children <18 years of age with OHCA, they should at least provide chest compressions (good practice statement). In the 2015 CoSTR, this was cited as a strong recommendation but based on very-low-quality evidence. | Rescuers who have been taught adult BLS or the chest compression-only sequence and have no specific knowledge of paediatric resuscitation may use this, as the outcome is worse if they do nothing. However, it is better to provide rescue breaths as part of the resuscitation sequence when applied to children as the asphyxial nature of most paediatric cardiac arrests necessitates ventilation as part of effective CPR. | In line with the international CoSTR, ERC paediatric guidelines now apply to any one under the age of 18. However, for practical purposes, ERC still advises to use the adult guidelines for anyone who appears to be an adult | Routine |
| Neonatal CPR | No new treatment recommendation | 3:1 compression to ventilation ratio is used for resuscitation at birth where compromise of gas exchange is nearly always the primary cause of cardiovascular collapse. Rescuers may consider using higher ratios (e.g., 15:2) if the arrest is believed to be of cardiac origin. After insertion of a tracheal tube or laryngeal mask airway, intermittent compressions and ventilations are continued at the appropriate ratio | No change | N/A |

Abbreviations: CI Confidence interval, CPR Cardiopulmonary resuscitation, CoSTR Consensus on Science and Treatment Recommendation, CV Compression ventilation, ERC European Resuscitation Council, ILCOR International Liaison Committee on Resuscitation.

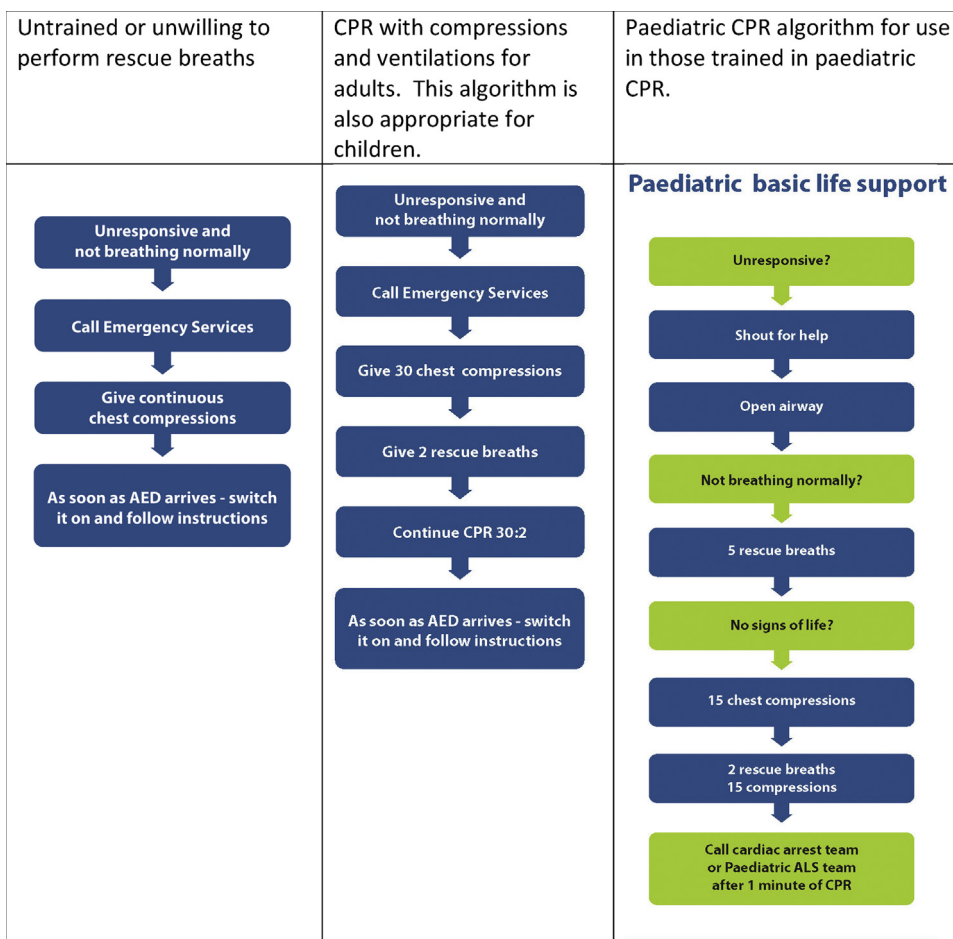


Fig. 1. ERC algorithms.

oxygenation typically with an oropharyngeal airway and simple oxygen mask passive oxygenation during CPR) [46].

ILCOR CoSTR in context of ERC guidelines

ILCOR made a strong treatment recommendation, based on high quality evidence that ‘EMS providers perform CPR with 30 compressions to 2 ventilations until a tracheal tube or supraglottic device has been placed’ [47]. ILCOR’s systematic review did not demonstrate any statistically significant benefit from continuous compression delivered by EMS compared to the conventional 30:2 control group [11].

In addition to the strong recommendation advocating for CPR with a compression to ventilation ratio of 30:2, ILCOR made a weak recommendation, on the basis of very low quality evidence, that when EMS systems have adopted the treatment bundle known as “minimally interrupted cardiac resuscitation”, this strategy is a reasonable alternative to conventional CPR for witnessed shockable out of hospital cardiac arrest. The treatment bundle described as “minimally interrupted cardiac resuscitation” involves continuous chest compressions with passive oxygenation typically with an oropharyngeal airway and simple oxygen mask. The ERC has not previously advocated the “minimally interrupted cardiac resuscitation” treatment bundle and note that ILCOR’s weak recommendation is limited to a narrow cohort of patients (witnessed, shockable rhythms). Given that the evidence does not show that “minimally invasive cardiac resuscitation” is superior to conventional 30:2 CPR, and that introducing a new approach would require additional training and resources, the ERC maintains its position

that it does not advocate the use of the “minimally interrupted cardiac resuscitation” treatment bundle.

Compression to ventilation ratio [48]

The ILCOR CoSTR suggests a compression to ventilation ratio of 30:2 in patients with cardiac arrest (weak recommendation, very-low-quality evidence). In the absence of any data addressing the critical outcomes, the Task Force placed a high value on maintaining consistency with the 2005, 2010, and 2015 CoSTRs.

ERC 2017 guidelines

The ERC maintains its recommendation that resuscitation should start with chest compressions, followed by a compression to ventilation ratio of 30:2 prior to securing the airway. For advanced life support providers, once the patient’s trachea has been intubated or a supraglottic airway (SGA) has been inserted, deliver uninterrupted chest compressions (except for rhythm/pulse checks and defibrillation when indicated) at a rate of 100–120 min⁻¹ and ventilate the lungs at approximately 10 breaths min⁻¹.

ILCOR CoSTR in context of ERC guidelines

The ERC has recommended a compression to ventilation ratio of 30:2 since 2005, having previously recommended a 15:2 ratio. This change occurred alongside changes in shock sequence (from three stacked shocks to single shocks), drug delivery (timing of adrenaline and amiodarone) and 2-min cycles between

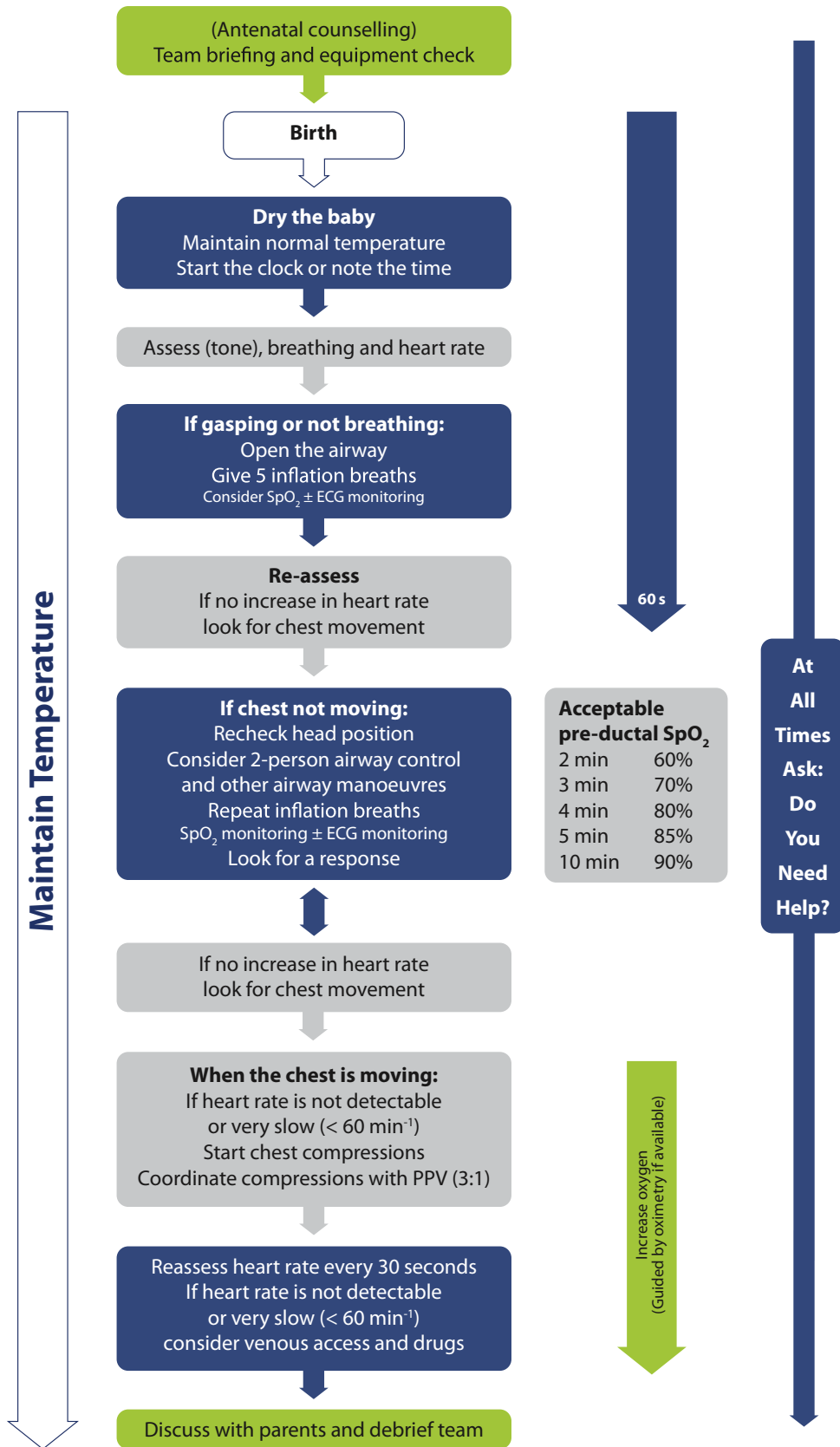


Fig. 2. Neonatal resuscitation algorithm.

rhythm checks). The ILCOR systematic review conducted a meta-analysis of seven observational studies. In a meta-analysis of these, the 30:2 compression to ventilation ratio demonstrated benefit for favourable neurological function (relative risk 1.34 [95% CI 1.02–1.76]; risk difference 1.72% [95% CI 0.52–2.91]) compared with the compression to ventilation ratio of 15:2.

In-hospital adult CPR [15]

The recent ILCOR systematic review on compression to ventilation ratios for CPR identified no new evidence to guide in-hospital CPR that has been published since the previous review in 2015 [49,50].

ERC 2017 guidelines

The key recommendations from the ERC remain to start CPR by giving 30 chest compressions followed by 2 ventilations. Once the patient's trachea has been intubated or a supraglottic airway (SGA) has been inserted, continue uninterrupted chest compressions (except for rhythm/pulse checks and defibrillation when indicated) at a rate of 100–120 min⁻¹ and ventilate the lungs at 10 breaths min⁻¹ [46].

ILCOR CoSTR in context of ERC guidelines

The ERC guidelines for in-hospital CPR remain in agreement with the new ILCOR CoSTR on compression to ventilation ratios. Specifically, the ERC suggests a compression to ventilation ratio of 30:2 compared with any other compression to ventilation ratio in patients with cardiac arrest. Whenever tracheal intubation or placement of a supraglottic device placement is achieved during in-hospital CPR, we suggest providers perform continuous compressions with positive pressure ventilations delivered without pausing chest compressions.

The ERC supports the ILCOR position not to recommend alterations to the 2005, 2010, and 2015 compression to ventilation ratio, and recognises that delivering continuous compressions is common in many settings where tracheal intubation or placement of SGAs is performed, including during in-hospital CPR. Furthermore, there is no evidence to suggest compression to ventilation ratios should be different for in-hospital CPR. The ERC notes the gaps in our knowledge stated by ILCOR, in particular the role on patient outcomes of continuous chest compressions, the effects of hyper-ventilation, and the impact of different airway techniques.

Bystander paediatric CPR [16]

The aetiology of cardiac arrests in children differs from the patterns seen in adults. A high proportion of cardiac arrests occur secondary to respiratory or circulatory failure rather than primary arrests caused by arrhythmias. This mandates consideration of whether a different approach from that advocated in adults should be used.

ERC 2017 guidelines

The ERC recommends that all children who sustain an out of hospital cardiac arrest should receive bystander CPR before arrival of EMS [51]. Rescuers who have been taught adult BLS or the chest compression-only sequence and have no specific knowledge of paediatric resuscitation may use either of these techniques, as the outcome is worse if they do nothing. However, it is better to provide rescue breaths as part of the resuscitation sequence for children

because most paediatric cardiac arrests are caused by asphyxia, which necessitates ventilation as part of effective CPR.

ILCOR CoSTR in context of ERC guidelines

The ILCOR systematic review summarised evidence from two large cohort studies [40,42]. Both studies showed better neurological outcomes (risk difference -3.30, 95% CI -4.88, -1.71), and survival (risk difference -7.04, 95% CI -9.58, -4.50) in children who received bystander CPR with compressions and ventilations compared with compression-only CPR. Since publication of the systematic review, two further studies have been published [52,53] which were also reviewed by the ILCOR Paediatric Task Force when considering the 2017 CoSTR. These studies were consistent with previous studies in showing that receiving any form of CPR was better than no CPR. The additional benefits of CPR with compressions and ventilations over compression only CPR was attenuated after adjustments for confounding variables. The uncertainty of the evidence prompted the Task Force to move from a strong to a weak recommendation stating that they 'suggest that bystanders provide CPR with ventilation for infants and children <18 years of age with OHCA (weak recommendation, very-low-quality evidence)'. The Task Force continues to recommend that if bystanders cannot provide rescue breaths as part of CPR for infants and children <18 years of age with OHCA, they should at least provide chest compressions (good practice statement). This position is consistent with the ERC recommendations above and the findings of a further study which was in press at the time of writing these guidelines [43].

Additional considerations

Although not directly addressed by the ILCOR CoSTR, the ERC writing group maintains its position of recommending the sequence of events for assessment and treatment of Airway (A), Breathing (B) and Circulation (C), although notes that there is equipoise as to whether this approach or one which prioritises compressions first (CAB) is superior.

In line with the international CoSTR, ERC paediatric guidelines now apply to any one under the age of 18. However, for practical purposes, the ERC still advises to use the adult guidelines for anyone who appears to be an adult. Our teaching materials will be updated in 2020 to reflect this.

Neonatal CPR

The recent ILCOR systematic review on compression to ventilation ratios for CPR identified no new evidence to guide CPR at birth since the CoSTR publication in 2015 [54].

ERC 2017 guidelines

The key recommendations from the ERC [55] remain that a 3:1 compression to ventilation ratio is used for resuscitation at birth where compromise of gas exchange is nearly always the primary cause of cardiovascular collapse. Rescuers may consider using higher ratios (e.g., 15:2) if the arrest is believed to be of cardiac origin. After insertion of a tracheal tube or supraglottic airway, intermittent compressions and ventilations are continued at the appropriate ratio (i.e. compressions are paused to deliver ventilations).

ILCOR CoSTR in context of ERC guidelines

The new ILCOR CoSTR on compression to ventilation ratios did not specifically mention the baby at birth or the neonatal age group because of a complete lack of any data.

Conclusion

The ERC acknowledges the quality and rigour of the evidence appraisal conducted by ILCOR. This enabled the findings from landmark studies published since the 2015 CoSTR to be incorporated into international resuscitation guidelines and educational strategies. The ERC review of the newly gathered evidence on CPR does not lead to any changes in the ERC teaching material or course content or programs. The review should enable laypeople and healthcare professionals to be confident that guidelines are based on the most up to date evidence. Implementation of the key messages from Guidelines 2015 with this timely update supports the ERC's mission to preserve human life by making high-quality resuscitation available to all.

Conflict of interest statement

All authors and contributors have formal roles within the ERC and their respective national resuscitation councils.

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