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| Question | |
| **Short PICO title here** | |
| **Population:** | Adults and children with out-of-hospital cardiac arrest (OHCA) |
| **Intervention:** | Any cardiopulmonary resuscitation (CPR) ratio delivered by emergency medical services (EMS) |
| **Comparison:** | Eligible comparator groups include a CPR ratio different from the one in the intervention arm delivered by EMS. Comparator groups that receive no CPR or compared manual CPR with mechanical CPR were excluded from the review. Studies including automated CPR or any use of mechanical devices will only be included if administered to all treatment arms. |
| **Main outcomes:** | Favourable neurological survival (as measured by cerebral performance category or modified Rankin Score) at discharge or 30-days and at any time interval after 30-days; Survival to discharge or 30 days survival; Survival to any time interval after discharge or 30 days survival; Return of spontaneous circulation (ROSC); Quality of life as measured by any indicator or score. |
| **Setting:** | Out-of-hospital setting |
| **Perspective:** |  |
| **Background:** | This topic was prioritised for review due to the time since the previous systematic review (Ashoor 2017 112) |
| **Conflict of interests:** | None |

# Assessment

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| Problem Is the problem a priority? | | |
| Judgement | Research evidence | Additional considerations |
| ○ No ○ Probably no ○ Probably yes X Yes ○ Varies ○ Don't know | Conventional cardiopulmonary resuscitation (CPR) consists of manual chest compressions and positive-pressure ventilation to maintain oxygenation until return of spontaneous circulation is achieved. During cardiopulmonary resuscitation (CPR), chest compressions are often interrupted to provide ventilation, undertake rhythm analysis or prioritise other tasks (sometimes in error). Data from animal studies indicate that ventilations can result in frequent interruptions in chest compressions which may reduce coronary and aortic blood flow during cardiac arrest and result in poorer outcomes (Kern 2002 645). Animal data also suggest that a CV ratio of 30:2 is associated with better haemodynamics and coronary perfusion pressure compared to 15:2 (Yannopoulos 2006 1444). One strategy to minimise pauses in chest compressions is to increase the compression to ventilation ratio, although this strategy risks a reduction in effective oxygenation during cardiac arrest. |  |
| Desirable Effects How substantial are the desirable anticipated effects? | | |
| Judgement | Research evidence | Additional considerations |
| ○ Trivial X Small ○ Moderate ○ Large ○ Varies ○ Don't know | For the critical outcome of favourable neurological survival at discharge or 30-days, we identified very low certainty evidence (downgraded for risk of bias and serious indirectness) from two cohort studies (Kudenchuk 2012 1787, Berdowski 2010 1101). In one cohort study (Kudenchuk 2012 1787), the implementation of the 2005 resuscitation guidelines consisting of a CV ratio of 30:2 (among other interventions) was associated with an improvement in neurologically favourable survival at hospital discharge compared to a prior period consisting of a CV ratio of 15:2 (OR 1.56, 95% CI: 1.11, 2.18). In comparison, the other study (Berdowski 2010 1101) found no change in outcomes for patients treated under the 2005 resuscitation guidelines.  For the critical outcome of survival to hospital discharge or 30-day survival, we identified very low certainty evidence (downgraded for risk of bias and serious indirectness) from six cohort studies. Five studies (Steinmetz 2008 908, Olasveengen 2009 407, Sayre 2009 469, Deasy 2011 984, Kudenchuk 2012 1787) involved retrospective before-after analyses of the implementation of the 2005 resuscitation guidelines, consisting of a CV ratio of 30:2 (compared to 15:2) among other resuscitation practice changes. In three cohort studies of OHCA from all rhythms, the implementation of a CV ratio of 30:2 compared to 15:2 improved the risk-adjusted odds of survival in Sayre 2009 469 (AOR 1.8 (95% CI: 1.2, 2.7) and Steinmetz 2008 908 (AOR 2.5, 95% CI: 1.4, 4.6), but not in Olasveengen 2009 407 (AOR 1.42, 95% CI: 0.79, 2.57). For OHCA with initially shockable rhythms, Deasy 2011 984 reported an improvement in the risk-adjusted odds of survival to hospital discharge with a CV ratio of 30:2 compared with 15:2 (AOR 1.62, 95% CI: 1.33-1.98), which was completely attenuated after adjustment for the temporal trend (AOR 1.07, 95% CI: 0.71, 1.62). In OHCA patients with initial non-shockable rhythms, the implementation of a CV ratio of 30:2 compared to 15:2 increased the risk adjusted odds of survival in Kudenchuk 2012 1787 (AOR 1.53, 95% CI: 1.14, 2.05), but not in Deasy 2011 984 (AOR 1.19, 95% CI: 0.82, 1.73). A before-after study (Garza 2009 2597) of 200 bystander witnessed OHCA from initial shockable rhythms reported an improvement in survival to hospital discharge following the implementation of a bundled change in resuscitation practice consisting of a CV ratio of 50:2 compared to 5:1 (AOR 2.17, 95% CI: 1.26-3.73).  For the critical outcome of return of spontaneous circulation, we identified very low certainty evidence (downgraded for risk of bias and serious indirectness) from one cohort study (Hostler 2007 446) of 1243 OHCA patients which showed no change in the risk-adjusted odds of return of spontaneous circulation with a CV ratio of 30:2 compared to 15:2 (OR 1.31, 95% CI: 0.99, 1.73). |  |
| Undesirable Effects How substantial are the undesirable anticipated effects? | | |
| Judgement | Research evidence | Additional considerations |
| X Trivial ○ Small ○ Moderate ○ Large ○ Varies ○ Don't know | Although a number of the studies included demonstrated no impact from the changes in practice that included a change in CV ratio, none demonstrated harmful impacts on patient outcomes. Among the six studies that were excluded from the review due to a lack of adjustment for confounding (Robinson 2010 1648, Aufderheide 2010 1357, Maisch 2010 998, Lick 2011 36, Schewe 2015 232, Yanagawa 2010 340), we also did not find any evidence of harm from the implementation of a CV ratio of 30:2. | There is some concern that higher CV ratios may increase rescuer fatigue. Simulation studies involving EMS and in-hospital staff have demonstrated conflicting findings on rescuer fatigue. A study involving EMS personnel indicated that 30:2 resulted in similar levels of fatigue compared to 15:2 (Yannopoulos 2006 1444), while another simulation study (Deschilder 2007 113) involving in-hospital staff indicated that 30:2 was more exhaustive than 15:2. The latter study did not find that this influenced CPR quality. |
| Certainty of evidence What is the overall certainty of the evidence of effects? | | |
| Judgement | Research evidence | Additional considerations |
| X Very low ○ Low ○ Moderate ○ High ○ No included studies | The certainty of evidence for all outcomes was very low, downgraded for risk of bias and serious indirectness. All studies included in this review suffered from serious indirectness, where a change to CV ratio was delivered or introduced as part of a bundle of care consisting of other changes, such as increases in CPR duration cycles, removal of stacked shocks, removal of post-shock rhythm checks and fewer interruptions to chest compressions. It is possible that the benefits observed in these studies are not related to a change in CV ratio, but other changes occurring at the same time. For instance, in one study (Rae 2006 2760), an improvement in survival to hospital discharge was observed in bystander witnessed OHCA from initial shockable rhythms after the implementation of the 2005 resuscitation guidelines without adopting the change to a CV ratio of 30:2. |  |
| Values Is there important uncertainty about or variability in how much people value the main outcomes? | | |
| Judgement | Research evidence | Additional considerations |
| ○ Important uncertainty or variability X Possibly important uncertainty or variability ○ Probably no important uncertainty or variability ○ No important uncertainty or variability | Only two studies were identified that provided adjusted estimates of the intervention effect for favourable neurological survival at discharge or 30-days. In one study (Kudenchuk 2012 1787), the implementation of the 2005 resuscitation guidelines consisting of a CV ratio of 30:2 was associated with an improvement in neurologically favourable survival at hospital discharge (Cerebral Performance Category score 1–2) compared to a prior period consisting of a CV ratio of 15:2. In another cohort study (Berdowski 2010 1101), patients treated under the 2005 resuscitation guidelines consisting of a CV ratio of 30:2 (among other interventions) was associated with no change in neurologically favourable survival at 30-days (Cerebral Performance Category score 1–2). No studies examined quality of life outcomes or longer-term patient outcomes. |  |
| Balance of effects Does the balance between desirable and undesirable effects favor the intervention or the comparison? | | |
| Judgement | Research evidence | Additional considerations |
| ○ Favors the comparison ○ Probably favors the comparison ○ Does not favor either the intervention or the comparison X Probably favors the intervention ○ Favors the intervention ○ Varies ○ Don't know | Despite the theoretical risk of suboptimal ventilations in patients receiving higher CV ratios, we did not identify any evidence of harm following the implementation of practice changes involving a CV ratio of 30:2 compared to 15:2. It is possible that higher CV ratios may introduce greater risk of suboptimal oxygenation and ventilation. |  |
| Resources required How large are the resource requirements (costs)?" | | |
| Judgement | Research evidence | Additional considerations |
| ○ Large costs ○ Moderate costs X Negligible costs and savings ○ Moderate savings ○ Large savings ○ Varies ○ Don't know | Negligible impact on resources as all CV ratios require similar investment in staff and resources. |  |
| Certainty of evidence of required resources What is the certainty of the evidence of resource requirements (costs)? | | |
| Judgement | Research evidence | Additional considerations |
| ○ Very low ○ Low ○ Moderate ○ High X No included studies | There were no economic evaluations of the two treatment strategies. |  |
| Cost effectiveness Does the cost-effectiveness of the intervention favor the intervention or the comparison? | | |
| Judgement | Research evidence | Additional considerations |
| ○ Favors the comparison ○ Probably favors the comparison X Does not favor either the intervention or the comparison ○ Probably favors the intervention ○ Favors the intervention ○ Varies ○ No included studies | All CV ratios identified in this review are likely to be as cost-effective as the control. |  |
| Equity What would be the impact on health equity? | | |
| Judgement | Research evidence | Additional considerations |
| ○ Reduced ○ Probably reduced X Probably no impact ○ Probably increased ○ Increased ○ Varies ○ Don't know | Unlikely that any CV ratio would enhance equitable access to resuscitation |  |
| Acceptability Is the intervention acceptable to key stakeholders? | | |
| Judgement | Research evidence | Additional considerations |
| ○ No ○ Probably no X Probably yes ○ Yes ○ Varies ○ Don't know | A CV ratio of 30:2 has been embedded in resuscitation guidelines since 2005. |  |
| Feasibility Is the intervention feasible to implement? | | |
| Judgement | Research evidence | Additional considerations |
| ○ No ○ Probably no ○ Probably yes X Yes ○ Varies ○ Don't know | The task force placed a high priority on consistency with our 2005, 2010, 2015 and 2020 treatment recommendations, which recommend the use of a CV ratio of 30:2. |  |

# Summary of judgements

|  | **Judgement** | | | | | | |
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| **Problem** | No | Probably no | Probably yes | **Yes** |  | Varies | Don't know |
| **Desirable Effects** | Trivial | **Small** | Moderate | Large |  | Varies | Don't know |
| **Undesirable Effects** | **Trivial** | Small | Moderate | Large |  | Varies | Don't know |
| **Certainty of evidence** | **Very low** | Low | Moderate | High |  |  | No included studies |
| **Values** | Important uncertainty or variability | **Possibly important uncertainty or variability** | Probably no important uncertainty or variability | No important uncertainty or variability |  |  |  |
| **Balance of effects** | Favors the comparison | Probably favors the comparison | Does not favor either the intervention or the comparison | **Probably favors the intervention** | Favors the intervention | Varies | Don't know |
| **Resources required** | Large costs | Moderate costs | **Negligible costs and savings** | Moderate savings | Large savings | Varies | Don't know |
| **Certainty of evidence of required resources** | Very low | Low | Moderate | High |  |  | **No included studies** |
| **Cost effectiveness** | Favors the comparison | Probably favors the comparison | **Does not favor either the intervention or the comparison** | Probably favors the intervention | Favors the intervention | Varies | No included studies |
| **Equity** | Reduced | Probably reduced | **Probably no impact** | Probably increased | Increased | Varies | Don't know |
| **Acceptability** | No | Probably no | **Probably yes** | Yes |  | Varies | Don't know |
| **Feasibility** | No | Probably no | Probably yes | **Yes** |  | Varies | Don't know |

# Type of recommendation

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| Strong recommendation against the intervention | Conditional recommendation against the intervention | Conditional recommendation for either the intervention or the comparison | Conditional recommendation for the intervention | Strong recommendation for the intervention |
| ○ | ○ | ○ | X | ○ |

# Conclusions

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| Recommendation |
| We suggest a compression–ventilation ratio of 30:2 compared with any other compression–ventilation ratio in patients with cardiac arrest (weak recommendation, very low-certainty evidence). |
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| Justification |
| • In making this recommendation, the task force placed a high priority on consistency with our 2005, 2010, 2015 and 2020 treatment recommendations and the findings identified in this review, which suggest that the bundle of care (which included changing to a CV ratio of 30:2 from 15:2) resulted in more lives being saved.  • We note that there would likely be substantial resource implications (e.g., reprogramming, retraining) associated with a change in recommendation, and an absence of any data addressing our critical outcomes to suggest our current recommendation should be changed.  • As all the studies identified in this review were undertaken around the time of the 2005 resuscitation guideline changes, the task force felt there was little benefit in further reviews examining a CV ratio of 15:2. Future studies and reviews should focus on the benefit of longer compression to ventilation ratios, compared to the current recommendation of 30:2.  • All studies included in this review suffered from serious indirectness, where a change to CV ratio was delivered or introduced as part of a bundle of care consisting of other changes, such as increases in CPR duration cycles, removal of stacked shocks, removal of post-shock rhythm checks and fewer interruptions to chest compressions. It is possible that the benefits observed in these studies are not related to a change in CV ratio, but other changes occurring at the same time.  • The task force excluded from this review five studies (Rae 2006 2760, Hung 2010 569, Becker 2008 22, Hinchey 2010 348, Bigham 2011 979) comparing patient outcomes between the 2005 and 2000 resuscitation guideline periods, because they either did not specify changes to CV ratios or did not adopt changes to CV ratios. In one study (Rae 2006 2760), an improvement in survival to hospital discharge was observed in bystander witnessed OHCA from initial shockable rhythms after the implementation of the 2005 resuscitation guidelines without adopting the change to 30:2. |

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| Subgroup considerations |
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| Implementation considerations |
| We note that there would likely be substantial resource implications (e.g., reprogramming, retraining) associated with a change in recommendation, and an absence of any data addressing our critical outcomes to suggest our current recommendation should be changed. |

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| Monitoring and evaluation |
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| Research priorities |
| Current knowledge gaps include but are not limited to:  1. What is the true effect 30:2 versus 15:2 without any other concurrent changes in practice?  2. Is there a benefit of longer compression to ventilation ratios, compared to 30:2?  3. What is the ability of CPR providers to deliver two effective ventilations during the short allotted pause in chest compressions during CPR?  4. Is there a ratio-dependent critical volume of air movement required to maintain oxygenation? |

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