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| Question | |
| **Should analysis of cardiac rhythm during chest compressions vs. standard care (analysis of cardiac rhythm during pauses in chest compressions) be used for Adults and children with cardiac arrest?** | |
| **Population:** | Adults and children with cardiac arrest |
| **Intervention:** | analysis of cardiac rhythm during chest compressions |
| **Comparison:** | standard care (analysis of cardiac rhythm during pauses in chest compressions) |
| **Main outcomes:** | Survival to hospital discharge with good neurological outcome and survival to hospital discharge were ranked as critical outcomes. Return of spontaneous circulation (ROSC) was ranked as an important outcome. CPR quality metrics such time chest compression fraction, pauses in compressions, compressions per minute, time to commencing CPR, or time to first shock etc. were included as important outcomes. |
| **Setting:** | In any setting (in-hospital or out-of-hospital) |
| **Perspective:** | All years and all languages were included as long as there was an English abstract; unpublished studies (e.g., conference abstracts, trial protocols) were excluded. Randomized controlled trials (RCTs) and non-randomized studies (non-randomized controlled trials, interrupted time series, controlled before-and-after studies, cohort studies) are eligible for inclusion. Unpublished studies (e.g., conference abstracts, trial protocols) are excluded. Literature search updated to Sept 23, 2019. |
| **Background:** | High quality CPR with few pauses in chest compressions is emphasized in current Guidelines and CPR teaching practices. Rhythm analysis and pulse checks cause pauses in chest compressions, and artifact-filtering algorithms for analysis of electrocardiographic rhythm during CPR has been proposed as a measure to reduce pauses in chest compressions. |
| **Conflict of interests:** | Kuzovlev (none), Olasveengen (unrestricted project support from Laerdal Foundation and Zoll Foundation) |

# Assessment

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| Problem Is the problem a priority? | | |
| Judgement | Research evidence | Additional considerations |
| ○ No ○ Probably no ○ Probably yes ● Yes ○ Varies ○ Don't know | High quality CPR with few pauses in chest compressions is emphasized in current Guidelines and CPR teaching practices. Rhythm analysis and pulse checks cause pauses in chest compressions, and artefact-filtering algorithms for analysis of electrocardiographic rhythm during CPR has been proposed as a measure to reduce pauses in chest compressions.    Although there are somewhat conflicting observations on the correlation between hands-off or chest compression pauses and patient outcomes, chest compressions are the sole source of forward blood flow during cardiac arrest in the BLS setting – and there is general consensus that measures to decrease pauses are important. Exessive pauses in chest compressions are commonly reported, and is regarded as a high priority problem. |  |
| Desirable Effects How substantial are the desirable anticipated effects? | | |
| Judgement | Research evidence | Additional considerations |
| ○ Trivial ○ Small ○ Moderate ○ Large ○ Varies ● Don't know | There are currently no human studies that address the identified critical outcomes criteria of favorable neurologic outcome, survival, or ROSC or the important outcomes criteria of CPR quality, time to commencing CPR, or time to first shock. | Initial studies suggest this technology has adequate sensitivity and specificity, and therefore has the potential to reduce pauses in chest compressions and improve CPR quality. |
| Undesirable Effects How substantial are the undesirable anticipated effects? | | |
| Judgement | Research evidence | Additional considerations |
| ○ Large ○ Moderate ○ Small ○ Trivial ○ Varies ● Don't know | There are currently no human studies that address the identified critical outcomes criteria of favorable neurologic outcome, survival, or ROSC or the important outcomes criteria of CPR quality, time to commencing CPR, or time to first shock. | Direct undesirable effects are unlikely, but adding any new technology to the resuscitation setting always has the unintended potential to further increase the complexity, thereby potentially reducing CPR quality. |
| Certainty of evidence What is the overall certainty of the evidence of effects? | | |
| Judgement | Research evidence | Additional considerations |
| ○ Very low ○ Low ○ Moderate ○ High ● No included studies | Fourteen full-text papers were identified and reviewed (Li 2007 131, Tan 2008 S409, Werther 2009 1301, Li 2012 78, Aramendi 2012 692, Babaeizadeh 2014 798, Gong, 2014 140438, Partridge 2015 133, Zhang 2016 67, Rad 2016 44, Gong 2017 471, Zhang 2017 111, Fumagalli 2018 248, Hu 2019 1), and while they did not evaluate the effect of artefact-filtering algorithms for analysis of electrocardiographic rhythm during CPR on any of our critical or important outcomes, they provided insights into the feasibility and potential benefits of this technology. Most of these studies use previously collected ECG, electrical impedance and/or accelerometer signals from cardiac arrests cases to evaluate the ability of various algorithms (Li 2007 131, Tan 2008 S409, Werther 2009 1301, Li 2012 78, Aramendi 2012 692, Babaeizadeh 2014 798, Zhang 2016 67, Gong 2017 471, Fumagalli 2018 248, Hu 2019 1) or machine learning (Rad 2016 44) to detect shockable rhythms during chest compressions. There are also studies evaluating artefact-filtering algorithms in animal models (Gong, 2014 140438, Zhang 2017 111) and simulation studies (Partridge 2015 133). Sensitivities and specificities are generally reported in the 90-99% range, but none of these studies have evaluated their use in real-time clinical settings. |  |
| 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 ○ Possibly important uncertainty or variability ● Probably no important uncertainty or variability ○ No important uncertainty or variability | Chest compressions are the sole source of forward blood flow during cardiac arrest in the BLS setting – and there is general consensus that measures to decrease pauses are important. Exessive pauses in chest compressions are commonly reported, and is regarded as a high priority problem. |  |
| 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 ○ Probably favors the intervention ○ Favors the intervention ○ Varies ● Don't know | As there is no evidence evaluating the effect of artefact-filtering algorithms for analysis of electrocardiographic rhythm during CPR on any clinical outcomes, it is not possible to balance desirable and undesirable effects |  |
| Resources required How large are the resource requirements (costs)? | | |
| Judgement | Research evidence | Additional considerations |
| ○ Large costs ● Moderate costs ○ Negligible costs and savings ○ Moderate savings ○ Large savings ○ Varies ○ Don't know | Artefact-filtering algorithms for analysis of electrocardiographic rhythm during CPR is new technology that needs to be integrated in defibrillator software, the exact cost of this software upgrade is not known. While some defibrillator manufacturers already provide this technology in their products as a supplement to rhythm analysis during pauses, upgrading defibrillators that currently do not have this technology is likely to need significant investment in equipment as well as training 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 ● No included studies | General requirements for education and training when implementing new elements in CPR algorithms is well recognized, but as EMS systems have pre-existing programs for regular training and re-training, the additional cost of each element or change is rarely studied. As development of new defibrillators might include several upgrades, the exact cost of the addition of filtering algorithms are not known. |  |
| 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 ○ Does not favor either the intervention or the comparison ○ Probably favors the intervention ○ Favors the intervention ○ Varies ● No included studies | As the science evaluating artefact-filtering algorithms for analysis of electrocardiographic rhythm during CPR is limmited to proof of concept studies demonstrating feasibility when applied off-line to collected signal data, any benefit to patient outcomes remains to be determined. |  |
| Equity What would be the impact on health equity? | | |
| Judgement | Research evidence | Additional considerations |
| ○ Reduced ● Probably reduced ○ Probably no impact ○ Probably increased ○ Increased ○ Varies ○ Don't know | As this is new technology to be integrated into expensive medical equipment, it is likely that access to this technology would be dependent on available resources within health care systems. Health equity would likely decrease. |  |
| Acceptability Is the intervention acceptable to key stakeholders? | | |
| Judgement | Research evidence | Additional considerations |
| ○ No ○ Probably no ○ Probably yes ● Yes ○ Varies ○ Don't know | There is broad agreement that minimizing pauses in chest compressions is a priority in CPR monitoring and training. As a intervention targeted towards reducing chest compression pauses, if the technology was actually shown to reduce compression pauses it is likely to be acceptable to stakeholders. We did identify a simulation study sponsored by a defibrillator manufacturer demonstrating reduced hands-off intervals using artefact-filtering algorithms for analysis of electrocardiographic rhythm during CPR (Partridge 2015 133). |  |
| Feasibility Is the intervention feasible to implement? | | |
| Judgement | Research evidence | Additional considerations |
| ○ No ○ Probably no ● Probably yes ○ Yes ○ Varies ○ Don't know | The fourteen full-text papers identified (Li 2007 131, Tan 2008 S409, Werther 2009 1301, Li 2012 78, Aramendi 2012 692, Babaeizadeh 2014 798, Gong, 2014 140438, Partridge 2015 133, Zhang 2016 67, Rad 2016 44, Gong 2017 471, Zhang 2017 111, Fumagalli 2018 248, Hu 2019 1) would collectively suggest artefact-filtering algorithms for analysis of electrocardiographic rhythm during CPR is feasible to implement. The studies using previously collected ECG, electrical impedance and/or accelerometer signals from cardiac arrests cases have generally shown the ability of these algorithms to identify shockable rhythms during compressions off-line (Li 2007 131, Tan 2008 S409, Werther 2009 1301, Li 2012 78, Aramendi 2012 692, Babaeizadeh 2014 798, Zhang 2016 67, Gong 2017 471, Fumagalli 2018 248, Hu 2019 1) or machine learning (Rad 2016 44). Their use in animal (Gong, 2014 140438, Zhang 2017 111) and simulation studies (Partridge 2015 133) would also support feasibility. |  |

# 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** | Large | Moderate | Small | Trivial |  | 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 |
| ○ | **●** | ○ | ○ | ○ |

# Conclusions

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| Recommendation |
| We suggest against the routine use of artifact-filtering algorithms for analysis of electrocardiographic rhythm during CPR (weak recommendation, very low certainty of evidence).    We suggest the usefulness of artifact-filtering algorithms for analysis of electrocardiographic rhythm during CPR be assessed in clinical trials or research initiatives (weak recommendation, very low certainty of evidence). |
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| Justification |
| In making a recommendation against routine use, we placed priority on avoiding the costs of introducing a new technology where the effectiveness or harm on patient outcomes remains to be determined.    In making a recommendation for further research; the task force is acknowledging a) there is thus far insufficient evidence to support a decision for or against routine use, b) further research has potential for reducing uncertainty about the effects and c) further research is thought to be of good value for the anticipated costs.    The task force also acknowledges that some EMS systems may already have implemented artifact-filtering algorithms for analysis of electrocardiographic rhythm during CPR, and as such wish to strongly encourage such systems to report on their experiences to build the evidence base regarding the use of these technologies in clinical practice. |

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| Subgroup considerations |
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| Implementation considerations |
| Artefact-filtering algorithms for analysis of electrocardiographic rhythm during CPR is new technology that needs to be integrated in defibrillator software, the exact cost of this software upgrade is not known. While some defibrillator manufacturers already provide this technology in their products as a supplement to rhythm analysis during pauses, upgrading defibrillators that currently do not have this technology is likely to need significant investment in equipment as well as training resources.  General requirements for education and training when implementing new elements in CPR algorithms is well recognized, but as EMS systems have pre-existing programs for regular training and re-training, the additional cost of each element or change is rarly studied. As development of new defibrillators might include several upgrades, the exact cost of the addition of filtering algorithms are not known. |

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| Monitoring and evaluation |
| The potential benefit of artefact-filtering algorithms for analysis of electrocardiographic rhythm during CPR is related to reducing pauses in chest compressions needed to provide perfusion to patients in cardiac arrest. In addition to demonstrating benefit for this new technology related to patient outcomes, studies should also monitor and report quality of CPR to ensure the intervention has the intended effect. |

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| Research priorities |
| · There were no studies identified that evaluated feasibility, efficacy or effectiveness of artifact-filtering algorithms for analysis of electrocardiographic rhythm during CPR in any setting for any patient population. |