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| Question |
| **Should use of additional modalities for heart rate assessment: ECG, doppler device, digital stethoscope, photoplethysmography, video plethysmography, dry electrode technology vs. COMPARISON: Compared with 1. Pulse oximetry with or without auscultation 2. Auscultation alone 3. In between intervention comparison be used for Newly born infants in the delivery room?** |
| **Population:** | Newly born infants in the delivery room |
| **Intervention:** | Use of additional modalities for heart rate assessment: ECG, doppler device, digital stethoscope, photoplethysmography, video plethysmography, dry electrode technology |
| **Comparison:** | COMPARISON: Compared with 1. Pulse oximetry with or without auscultation 2. Auscultation alone 3. In between intervention comparison |
| **Main outcomes:** | Unanticipated admission to neonatal intensive care unit (I)Death before hospital discharge (C)Duration of positive pressure ventilation (PPV) in delivery room from the start of PPV (I) Tracheal intubation in delivery room (I)Chest compressions or epinephrine (adrenaline) in delivery room (I)Time from birth to heart rate ≥100 bpm as measured by ECG (I)Resuscitation team performance in the delivery room (I)  |
| **Setting:** | Delivery Room |
| **Perspective:** | Population perspective |
| **Background:** |  |
| **Conflict of interests:** | VK has authored one of the studies included in the systematic review but did not participate in the decision to include the study or RoB assessment of the study.  |

# Assessment

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| ProblemIs the problem a priority? |
| Judgement | Research evidence | Additional considerations |
| ○ No○ Probably no○ Probably yes● Yes○ Varies○ Don't know | - Annually 140 million neonates are born worldwide and up to 5% of term neonates will not initiate adequate respiratory effort after stimulation by drying and warming. More than 7 million newborn infants will require positive pressure ventilation (PPV) every year for heart rate below 100 beats per minute (bpm) or gasping or apnea. Rising heart rate (HR) is the most important indicator of effective positive pressure ventilation in initially bradycardic newborns. [Wyckoff 2020 S185] HR is critical to decision-making in the delivery room, and therefore accurate assessment of HR is a priority. -Although there have been multiple studies investigating latency and accuracy of various modalities for HR determination in the delivery room (DR), there is limited evidence to date of what the impact of the methodology of heart rate assessment on clinical outcomes might be {Kamlin 2008 758; Dawson 2013 957 958; van Vonderen 2015 51; Iglesias 2018 F236; Henry 2020 75} | - Fast, accurate and continuous HR estimation is desirable during neonatal resuscitation as it allows the team to make decisions and determine effectiveness of the resuscitation efforts.- Underestimating HR can lead to interventions when not indicated, such as PPV, intubation, chest compressions and epinephrine administration. This may lead to harm. On the other hand, overestimation of HR may result in a delay of necessary critical interventions, such as PPV, intubations, chest compressions and potentially result in adverse outcomes. [ Phillipos 2016 130]-Recommendation for method of HR assessment varies across the different resuscitation councils of the world.  |
| Desirable EffectsHow substantial are the desirable anticipated effects? |
| Judgement | Research evidence | Additional considerations |
| ○ Trivial○ Small○ Moderate○ Large○ Varies● Don't know | -The evidence suggests that ECG is faster in acquiring HR in the delivery room compared to auscultation with pulse oximeter {Murphy 2018 F490}. Auscultation with pulse oximeter is less accurate compared to ECG in estimating HR in the delivery room for the first few minutes after birth {Kamlin 2006 320; Murphy 2018 F491}. - Pulse oximeter is less accurate than ECG {Kamlin 2008 758; Dawson 2013 957; Van Vonderen 2015 51; Abbey 2021 6; Henry 2020 75} as it was shown in 28,211 observations [Mean Bias -1.2; LoA (95%CI): -17.9 to 15.5 (-32.8, 30.4)]. - Single cohort study with 48 newborns and 755 data pairs {Van Vonderen 2015 51} showed that pulse oximeter is less accurate than ECG to detect heart rate below 100 bpm up to 300 seconds.- Single RCT {Abbey 2021 4} with 51 premature newborns infants showed no difference in the duration of PPV between ECG and pulse oximeter (ECG: 345s (120,558) vs. PO: 196s (150,273); p=0,37). -Single before-after observational study {Shah 2019 15} involving 632 newborn infants showed association of decrease in delivery room tracheal intubations with ECG use (aOR0.65, 95% CI 0.45-0.94]. In small randomized controlled trials involving 91 newborns no decrease in endotracheal intubation was noted with ECG use in the delivery room (RR 1.34, 95% CI 0.69-2.59) {Katheria 2017 6; Abbey 2021 4}. ). The certainty for this evidence remains low due to risk of bias and imprecision. | -ECG allows for continuous HR assessment compared to auscultation, which offers intermittent HR assessment.- ECG allows continuous visualization of HR while auscultation relies on a team member who needs to count audible heart beats over a period of time using a stethoscope. - There have been no studies examining the impact of ECG use in the delivery room on resuscitation team performance.- Randomized controlled trial evidence of the impact of HR assessment method on outcomes for very low birth weight (VLBW) infants and infants needing intubation or cardiopulmonary resuscitation (CPR) in the delivery room remain extremely limited {Katheria 2017 6 ; Abbey 2021 4}. Additional studies are needed to assess effect of ECG use for HR assessment in the DR on these important subgroups of infants.  |
| Undesirable EffectsHow substantial are the undesirable anticipated effects? |
| Judgement | Research evidence | Additional considerations |
| ○ Large○ Moderate○ Small○ Trivial○ Varies● Don't know | * One before-after observational study including 632 infants showed increased incidence of chest compressions with ECG monitoring [(aOR 3.59, 95% CI 1.36-9.46)] {Shah 2021 15}. This study had a higher baseline rate of chest compressions (3%) when compared to previously described incidence of chest compressions in newly born infants. Authors did not assess compliance with NRP guidelines in infants receiving chest compressions. It remains unclear if temporal trends and other confounders played a role in increase in chest compressions with the use of ECG monitoring in DR. Interestingly, the incidence of epinephrine use in the delivery room was no different between two groups {Shah 2021 15}.
* Small randomized controlled trials did not show any change in the incidence of chest compressions with ECG use in the delivery room {Katheria 2017; Abbey 2021 4}. These studies were not powered to find a difference in incidence of chest compressions.
 | * It is also important to note that the appropriate HR threshold for chest compressions in newly born infant remains a knowledge gap.
* It remains unclear if the timing of cord clamping, especially in relation to the aeration of the lungs, impacts rate of bradycardia in newly born infants at birth. Immediate cord clamping may result in drop in left ventricular output and may result in bradycardia at the time of birth. Recognition of such bradycardia by tools that measure HR faster than auscultation with/without pulse oximeter may result in an increase in resuscitation interventions. It remains unclear if this is beneficial or harmful.
* There is limited data on use of ECG for delivery room resuscitation of VLBW infants. Application of leads to very/extremely premature skin may cause skin damage or may result in increased incidence of hypothermia if the plastic wrap used for thermoregulation is being repeatedly undone.
* It remains unclear if the use of ECG will result in delay or non-recognition of pulseless electrical activity in a newly born infant.
* It remains unclear if underestimation or overestimation of heart rate by pulse oximetry or auscultation will result in inappropriate interventions or delay in critical interventions such as positive pressure ventilation during neonatal resuscitation.
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| Certainty of evidenceWhat is the overall certainty of the evidence of effects? |
| Judgement | Research evidence | Additional considerations |
|  ○ Very low● Low○ Moderate○ High○ No included studies | * There was low certainty of evidence of decrease in the important outcome of tracheal intubation in the delivery room from 1 observational study, but benefit or harm could not be excluded for the same outcome from low certainty evidence obtained from 2 RCTs.
* Similarly, there was low certainty of evidence of increase in chest compressions in the DR from 1 observational study, but benefit or harm could not be excluded for the important outcome of chest compressions in the DR from 2 RCTs as event rate was zero in both studies.
* For important outcomes of duration of PPV and time from birth to HR ≥ 100 bpm, certainty of evidence was very low due to risk of bias and serious imprecision.
* For the critical outcome of death before discharge, evidence was of a low certainty downgraded for risk of bias and imprecision.
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| ValuesIs 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 | * There is probably no important uncertainty or variability in how much people value death before discharge and unanticipated admission to the neonatal intensive care unit as outcomes.
* Other outcomes are process outcomes or surrogate outcomes. For other outcomes, there is possibly important uncertainty or variability.
* We included outcomes that were previously judged to be critical or important by an expert panel and thus are likely to influence healthcare providers to use one method of HR monitoring over another in the DR.
 | Outcome ratings were adopted from the following publication: [Strand 2020 328] |
| Balance of effectsDoes 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 | Certainty of current evidence is low. The desirable and undesirable effects of use of ECG in the delivery room remain unclear.  |  |
| Resources requiredHow 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 | Costs of ECG monitoring in the delivery room are context-dependent. Many centers are able to re-allocate monitors from existing resources; others providers will need to allocate resources to buy additional monitors. Beyond the ECG monitor, the cost of using disposable leads (gel electrodes) and costs associated with training may be considered. As such, it is deemed a moderate cost.  | It is possible that the routine use of ECG for heart rate assessment in infants receiving positive pressure ventilation immediately after birth may reduce the need for further neonatal resuscitation interventions and long-term undesirable outcomes. There is no current evidence to support that use of ECG will alter need for resuscitation interventions or clinical outcomes in newly born infants.  |
| Certainty of evidence of required resourcesWhat is the certainty of the evidence of resource requirements (costs)? |
| Judgement | Research evidence | Additional considerations |
| ○ Very low○ Low○ Moderate○ High● No included studies | There is no evidence currently available to answer this question.  |  |
| Cost effectivenessDoes 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 | There is no evidence currently available to answer this question.  |  |
| EquityWhat 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 | There are no data available to inform the answer to this question.  | A preponderance of neonatal asphyxia occurs in resource-limited areas. We speculate that an affordable heart rate assessment tool that provides rapid and accurate data may positively impact outcomes in areas where neonatal asphyxia is more prevalent.We speculate that equipment and adequately trained personnel to perform the intervention may not always be available, especially in low-resource settings.  |
| AcceptabilityIs the intervention acceptable to key stakeholders? |
| Judgement | Research evidence | Additional considerations |
| ○ No○ Probably no○ Probably yes○ Yes● Varies○ Don't know | * Stakeholders have variable acceptance of this intervention
* We speculate this is predominantly due to the lack of evidence of impact on outcomes and cost-effectiveness.
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| FeasibilityIs the intervention feasible to implement? |
| Judgement | Research evidence | Additional considerations |
| ○ No○ Probably no● Probably yes○ Yes○ Varies○ Don't know | Multiple studies have demonstrated feasibility of use of ECG in newly born infants in various settings {Perlman 2015 S207}.  | Number of infants needing tracheal intubations or CPR {Katheria 2017 6 ; Shah 2019 15; Abbey 2021 4} and number of VLBW infants (Iglesías 2016 272) included in the studies are limited. |

# 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 |
| * Where resources permit, we suggest that the use of ECG for heart rate assessment of a newly born infant requiring resuscitation in the delivery room is reasonable (weak recommendation, low certainty of evidence).
* Where ECG is not available, auscultation with pulse oximetry is a reasonable alternative for heart rate assessment but the limitations of these modalities should be kept in mind (weak recommendation, low certainty of evidence).
* There is insufficient evidence to make a treatment recommendation regarding use of digital stethoscope, audible or visible Doppler US, dry electrode technology, reflectance-mode green light photoplethysmography and or transcutaneous electromyography of the diaphragm for heart rate assessment of a newborn in the delivery room.
* Auscultation with or without pulse oximetry should be used to confirm the heart rate when ECG is unavailable, not functioning or when pulseless electrical activity is suspected.

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| Justification |
| * Low certainty evidence from 3 studies inform this recommendation {Katheria 2017; Abbey 2021; Shah 2019}.
* Evidence from a recent ILCOR COSTR suggests that ECG does provide more rapid and more accurate assessment of heart rate in the delivery room than any of the alternative methods. However, it remains unclear if this level of speed and precision translates to clinically relevant differences in resuscitation interventions or clinical outcomes for newly born infants.
* One needs to balance the desire to have a rapid, continuous and accurate heart rate assessment in newly born infants needing resuscitation with the potential cost of ECG monitoring in the delivery room. This is especially true in the face of a lack of high certainty data regarding clinical impact of routine ECG use for heart rate assessment in newly born infants in the delivery room. Individual councils should take into account the available resources, values and preferences while creating local guidelines for recommended modalities for HR assessment in the delivery room.
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| Subgroup considerations |
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| Implementation considerations |
| Acquiring ECG monitors in the delivery room: many centers might be able to re-allocate monitors from existing resources; others providers will need to allocate resources to buy additional monitors. Use of ECG for HR assessment for newly born infants will require training of resuscitation team personnel.  |

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| Monitoring and evaluation |
| Continued monitoring and evaluation of resuscitation team performance and clinical outcomes, including resuscitation interventions is recommended.  |

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| Research priorities |
| * Does use of ECG or other modalities for heart rate assessment improve neonatal outcomes (unanticipated admission to neonatal intensive care unit, death before hospital discharge, duration of PPV in delivery room from the start of PPV, tracheal intubation in delivery room, chest compressions or epinephrine (adrenaline) in delivery room, time from birth to heart rate ≥100 bpm as measured by ECG)?
* Impact of ECG or other modalities for HR measurement on resuscitation team performance
* Impact of ECG and other modalities for HR assessment on equity
* Cost effectiveness of different modalities for HR assessment in the delivery room
* Should the HR assessment method in the delivery room be different for vigorous versus non-vigorous newly born infants?
* HR assessment method for a subgroup of infants who require intubation and/or CPR in the delivery room
* HR assessment method for VLBW infants
* Prevalence of bradycardia in a newly born infant after change in ILCOR recommendations for delayed cord clamping
* Prevalence of pulseless electrical activity for newly born infants in the DR
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