NEONATAL LIFE SUPPORT

Maintaining Normal Temperature Immediately After Birth in Late Preterm and Term Infants (SysRev)

Rationale for Review

A previous SysRev conducted for ILCOR concluded that there was a dose-responsive association between hypothermia on admission to a neonatal unit or postnatal ward and increased risk of mortality and other adverse outcomes.[139] A systematic review estimated that hypothermia was common in infants born in hospitals (prevalence range, 32% to 85%) and homes (prevalence range, 11% to 92%), even in tropical environments.[140] A SysRev was initiated from a priority list from the ILCOR Neonatal Life Support (NLS) Task Force (PROSPERO; registration CRD42021270739).[Liley, 2022 ####] The full text of this review can be found on the ILCOR website.[141]

Population, Intervention, Comparator, Outcome, Study Design, and Time Frame

- **Population:** Late preterm and term newborn infants (≥34 weeks' gestation)
- **Intervention:** Increased room temperature 23.0°C or warmer, thermal mattress, plastic bag or wrap, hat, heating and humidification of gases used for resuscitation, radiant warmer (with or without servo control), early monitoring of temperature, warm bags of fluid, warmed swaddling/clothing, skin-to-skin care with a parent, or any combination of these interventions
- **Comparator:** Drying, without any of the above interventions, and comparisons between interventions
- **Outcome:**
  - Critical: Survival

- Important: Rate of normothermia on admission to neonatal unit or postnatal ward; rate of hypothermia and hyperthermia on admission to neonatal unit or postnatal ward; response to resuscitation (eg, need for assisted ventilation, highest F_{IO_2}). For this and all subsequent reviews, importance of outcomes was in accord with Strand et al[142] or by consensus of the task force for outcomes specific to each review. Additional outcomes are included in the full online CoSTR.[141] For the purposes of the review, the definitions in in Table 18 were used.[143]

Table 18. Temperature Terminology

Term	Body temperature	
Moderate hypothermia	32.0˚C–35.9˚C	Measured using a digital, mercury, or contactless thermometer (axillary, rectal, or other defined site), on admission to a postnatal ward or neonatal unit; or if admission temperature not reported, temperature measured between 30 and 60 min of age.
Cold stress	36˚C to 36.4˚C	
Hyperthermia	>37.5˚C	

- **Study design:** RCTs and nonrandomized studies (non-RCTs, interrupted time series, controlled before-and-after studies, cohort studies) were eligible for inclusion. Unpublished studies were excluded.
- **Time frame:** All years and all languages were included if there was an English abstract. The literature search was conducted to August 2, 2021.

Consensus on Science

The SysRev identified 35 studies (25 RCTs including 4625 participants[144-168] and 10 observational studies[169-178] including >3342 participants [number not reported in 1 study]). All RCTs had eligibility criteria that excluded some or all infants who were at high risk of needing resuscitation or who received resuscitation. The studies were conducted in high-, middle-, and

low-income countries, but few interventions were studied in all settings. None of the studies included out-of-hospital births. Temperature outcomes were reported in a wide variety of ways, constraining the meta-analysis. There were insufficient data to conduct any of the prespecified subgroup analyses.

Comparison 1: Increased Room Temperature Compared With No Increased Room Temperature for Late Preterm and Term Newborn Infants

The SysRev identified 1 cluster-RCT including 825 late preterm and term newborn infants for this comparison.[151] All were born by caesarean section, so the study pertains specifically to operating room temperatures and only temperatures of 20ºC and 23ºC were compared. Data relating to the key critical and important outcomes for this comparison are summarized in Table 19. Evidence for additional outcomes evaluated is included in the full online CoSTR.[141]

Table 19. Increased Room Temperature Compared With No Increased Room Temperature for Late Preterm and Term Newborn Infants

Outcomes (importance)	Participants (studies), n	Certainty of the evidence (GRADE)	RR (95% CI)	Anticipated absolute effects (n)	
				Risk with room temperature 20ºC	RD with room temperature 23ºC
Normothermia on admission (important)	825 (1 RCT) Duryea et al,[151] 2016	Very low	1.26 (1.11–1.42)	449 per 1000	130 more infants per 1000 (55 more–209 more) were normothermic when 23ºC was used
Temperature on admission (important)	825 (1 RCT) Duryea et al,[151] 2016	Very low	Not applicable	Mean temperature 36.4°C	MD 0.3ºC higher (0.23ºC higher–0.37ºC higher) when 23ºC was used
Moderate hypothermia (<36^{0}C) (important)	825 (1 RCT) Duryea et al,[151] 2016	Very low	0.26 (0.16–0.42)	189 per 1000	140 fewer infants per 1000 (158 fewer–109 fewer) were moderately

Outcomes (importance)	Participants (studies), n	Certainty of the evidence (GRADE)	RR (95% CI)	Anticipated absolute effects (n)	
				Risk with room temperature 20ºC	RD with room temperature 23ºC
					hypothermic when 23ºC was used
Hyperthermia (>37.5ºC) (important)	825 (1 RCT) Duryea et al,[151] 2016	Very low	4.13 (0.88–19.32)	5 per 1000	15 more infants per 1000 (1 fewer–87 more) were hyperthermic when 23ºC was used

GRADE indicates Grading of Recommendations Assessment, Development, and Evaluation; MD, mean difference; RCT, randomized controlled trial; RD, risk difference; and RR, risk ratio.

Comparison 2. Skin-to-Skin Care With a Parent Versus No Skin-to-Skin Care for Late Preterm and Term Infants

The SysRev found 10 RCTs including 1668 late preterm and term newborn infants for this comparison.[147,149,153-156,159,162,163,165]

Data relating to key critical and important outcomes are shown in Table 20. Evidence for additional outcomes evaluated is included in the full online CoSTR.[141]

Table 20. Skin-to-Skin Care With a Parent Versus No Skin-to-Skin Care in Late Preterm and Term Newborn Infants

Outcomes (importance)	Participants (studies), n	Certainty of the evidence (GRADE)	RR (95% CI)	Anticipated absolute effects (n)	
				Risk with no skin-to-skin care	RD with skin-to-skin care
Survival to hospital discharge (critical)	203 (1 RCT) Ramani et al,[162] 2018	Very low	Insufficient events to determine the rate		
Normothermia on admission (important)	551 (3 RCTs) Ramani et al,[162] 2018 Safari et al,[163] 2018 Srivastava et al,[165] 2014	Very low	1.39 (0.91–2.12)	614 per 1000	239 more infants per 1000 (55 fewer–688 more) were normothermic when skin-to-skin care was used
Temperature on admission (important)	1048 (8 RCTs) Carfoot et al,[147] 2005	Very low	Not applicable	Mean temperature 36.5ºC	MD 0.32ºC higher (0.1ºC higher–0.54ºC

Outcomes (importance)	Participants (studies), n	Certainty of the evidence (GRADE)	RR (95% CI)	Anticipated absolute effects (n)	
				Risk with no skin-to-skin care	RD with skin-to-skin care
	Christensson et al,[149] 1992 Huang et al,[153] 2019 KoÇ et al,[155] 2017 Kollman et al,[156] 2017 Ramani et al,[162] 2018 Safari et al,[163] 2018 Srivastava et al,[165] 2014				higher) when skin-to-skin care was used
Hypoglycemia (Important)	100 (1 RCT) KoÇ et al,[155] 2017	Very low	0.16 (0.05–0.53)	326 per 1000	273 fewer infants per 1000 (309 fewer–153 fewer) were hypoglycemic when skin-to-skin care was used
Admission to NICU (Important)	512 (3 RCTs) Kollman et al,[156] 2017 Marín Gabriel et al,[159] 2010 Ramani et al,[162] 2018	Very low	0.34 (0.14–0.83)	70 per 1000	46 fewer infants per 1000 (60 fewer–12 fewer) were admitted to the NICU when skin-to-skin care was used

GRADE indicates Grading of Recommendations Assessment, Development, and Evaluation; MD, mean difference; NICU, neonatal intensive care unit; RCT, randomized controlled trial; RD, risk difference; and RR, risk ratio.

Comparison 3. Plastic Bag or Wrap Compared With No Plastic Bag or Wrap for Late Preterm and Term Newborn Infants

The SysRev found 3 RCTs including 794 late preterm and term newborn infants for this comparison.[146,154,158,164] Data relating to key critical and important outcomes are shown in Table 21. Evidence for additional outcomes evaluated is included in the full online CoSTR.[141] Of note

this comparison included studies where infants had been dried or not dried prior to use of the plastic bag or wrap.

Table 21. Plastic Bag or Wrap Compared With No Plastic Bag or Wrap for Late Preterm and Term Newborn Infants

Outcomes (importance)	Participants (studies), n	Certainty of the evidence (GRADE)	RR (95% CI)	Anticipated absolute effects (n)	
				Risk with standard care	RD with plastic bag or wrap plus standard care
Survival to hospital discharge (critical)	305 (2 RCTs) Leadford et al,[158] 2013 Shabeer et al,[164] 2018	Very low	0.95 (0.60–1.51)	981 per 1000	49 fewer infants per 1000 (392 fewer–500 more) died when a plastic bag or wrap was used
Normothermia on admission (important)	305 (2 RCTs) Leadford et al,[158] 2013 Shabeer et al,[164] 2018	Very low	1.50 (1.20–1.89)	406 per 1000	203 more infants per 1000 (81 more–3629 more) were normothermic when a plastic bag or wrap was used
Temperature on admission (important)	425 (3 RCTs) Cardona-Torres et al,[146] 2012 Leadford et al,[158] 2013 Shabeer et al,[164] 2018	Very low	Not applicable	Mean temperature 36.3ºC	MD 0.29ºC higher (0.2ºC higher–0.37ºC higher) when a plastic bag or wrap was used

GRADE indicates Grading of Recommendations Assessment, Development, and Evaluation; MD; mean difference; RCT, randomized controlled trial; RD, risk difference; and RR, risk ratio.

Comparison 4. Plastic Bag or Wrap Combined With Skin-To-Skin Care Compared With Skin-To-Skin Care Alone for Late Preterm and Term Newborn Infants

The SysRev found 2 RCTs including 698 late preterm and term newborn infants for this comparison.[145,167] Data relating to key critical and important outcomes are shown in Table 22. Evidence for additional outcomes evaluated is included in the full online CoSTR.[141] This comparison included studies where infants had been dried or not dried prior to use of the plastic bag or wrap.

Table 22. Plastic Bag or Wrap Combined With Skin-to-Skin Care Compared With Skin-to-Skin Care Alone for Late Preterm and Term Newborn Infants

Outcomes (importance)	Participants (studies), n	Certainty of the evidence (GRADE)	RR (95% CI)	Anticipated absolute effects (n)	
				Risk with skin-to-skin care alone	RD with plastic bag or wrap plus skin-to-skin care
Survival to hospital discharge (critical)	271 (1 RCT) Belsches et al,[145] 2013	Low	All infants in both groups survived		
Normothermia on admission (important)	692 (2 RCTs) Belsches et al,[145] 2013 Travers et al,[167] 2021	Low	1.39 (1.08–1.79)	221 per 1000	86 more infants per 1000 more (18 more–174 more per 1000) were normothermic when a plastic bag or wrap was added
Temperature on admission (important)	692 (2 RCTs) Belsches et al, 2013[145] Travers et al, 2021[167]	Low	Not applicable	Mean body temperature 36.0ºC	MD 0.2ºC higher (0.1ºC higher–0.3ºC higher) when a plastic bag or wrap was added
Admission to NICU or special care unit (important)	275 (1 RCT) Belsches et al,[145] 2013	Low	0.26 (0.03–2.26)	29 per 1000	21 fewer infants per 1000 (28 fewer–36 more per 1000) were admitted to a NICU or special care unit when a plastic bag or wrap was added
Hyperthermia (>37.5°C) (important)	692 (2 RCTs) Belsches et al,[145] 2013 Travers et al,[167] 2021	Very low	1.02 (0.08–12.85)	3 per 1000	0 more infants per 1000 (3 fewer–34 more per 1000) were hyperthermic when a plastic bag or wrap was added

GRADE indicates Grading of Recommendations Assessment, Development, and Evaluation; MD, mean difference; NICU, neonatal intensive care unit; RCT, randomized controlled trial; RD, risk difference; and RR, risk ratio.

For all other comparisons, no evidence-to-decision tables were developed, either because only single studies providing very low–certainty evidence were available or because no studies were found. Additional details on these comparisons are included in the online CoSTR.[141]

Treatment Recommendations

In late preterm and term newborn infants (≥34 weeks' gestation), we suggest the use of room temperatures of 23ºC compared to 20ºC at birth in order to maintain normal temperature (weak recommendation, very low–certainty evidence).

In late preterm and term newborn infants (≥34 weeks' gestation) at low risk of needing resuscitation, we suggest the use of skin-to-skin care with a parent immediately after birth rather than no skin-to-skin care to maintain normal temperature (weak recommendation, very low–certainty evidence).

In some situations where skin-to-skin care is not possible, it is reasonable to consider the use of a plastic bag or wrap, among other measures, to maintain normal temperature (weak recommendation, very low–certainty evidence).

In late preterm and term newborn infants ≥34 weeks' gestation, for routine use of a plastic bag or wrap in addition to skin-to-skin care immediately after birth compared with skin-to-skin care alone, the balance of desirable and undesirable effects was uncertain. Furthermore, the values, preferences, and cost implications of the routine use of a plastic bag or wrap in addition to skin-to-skin care are not known and, therefore, no treatment recommendation can be formulated.

Justification and Evidence-to-Decision Framework Highlights

The complete evidence-to-decision tables are provided in Appendix A.

In making these recommendations, the NLS Task Force considered that the review found evidence to support each of 3 interventions, without evidence of adverse effects. Each of these interventions was thought likely to be low in cost and feasible in many settings.

In many facilities, immediate newborn infant care (including resuscitation if needed) takes place in the delivery or operating room, and it may not be practicable to alter room temperatures for very preterm births and not others. Where a designated resuscitation room with separate temperature control is used, more individualised ambient temperature control may be feasible. Higher (>23°C) ambient temperatures have not been studied for late preterm and term infants. The adverse outcomes of maternal or neonatal hyperthermia could increase at higher ambient temperatures. Mortality may be increased among hyperthermic newborn infants,[179] and hypoxic ischemic encephalopathy may be exacerbated by hyperthermia.[180]

For skin-to-skin care, there is insufficient evidence to make a recommendation for newborn infants at high risk of needing resuscitation because of the inclusion criteria of available studies. There is a much larger evidence base supporting the use of skin-to-skin care in preterm and term infants for a variety of maternal and neonatal outcomes.[181,182] Studies report some barriers to use, but overall, skin-to-skin care is judged to be acceptable by both parents and caregivers.[183-185] Skin-to-skin care is likely to be cost-effective, acceptable, and feasible in high-, middle-, and low-income countries.

For routine use of a plastic bag or wrap for late preterm and term newborn infants 34 weeks' or greater gestation, the balance of desirable and undesirable effects was considered uncertain because of the potential for unmeasured undesirable effects. These could include that a plastic bag or wrap might be seen as an alternative or impediment to skin-to-skin care. When used in combination with warming devices, there could be risk of hyperthermia. Costs to clinical services could be high if they were used for a high proportion of late preterm and term infants. The environmental impact was also considered. Cultural values and maternal preferences in relation to this specific intervention are not known. Although the NLS Task Force agreed that

skin-to-skin care was preferred, a plastic bag or wrap may be reasonable when skin-to-skin care is not possible, especially for late preterm and low-birth-weight newborn infants, births in which ambient temperatures are low and cannot be increased, when alternative equipment (eg, radiant warmer, incubator, thermal mattress) is not available, or combinations of these circumstances.

The use of skin-to-skin care is likely to improve equity because of the low cost and feasibility for low- or middle-income countries. Room temperatures may or may not be easily adjustable in various settings. Where a room temperature of 23ºC cannot be achieved, the importance of skin-to-skin care may be greater.

The overall balance of risks and benefits for the use of a plastic bag or wrap combined with skin-to-skin care was considered uncertain because there was concern plastic bags or wraps might impair the acceptability or safety of skin-to-skin care and, thereby, cause harm. As with the use of a plastic bag or wrap compared with standard care, costs may be a barrier, particularly in low-income countries, if the intervention was applied to a high proportion of births.

Task Force Knowledge Gaps

Additional gaps are included in the full online CoSTR.

- The balance of risks and benefits for each evidence-based intervention when combined with other interventions
- The best methods of maintaining normothermia in infants who received or were at high risk of receiving resuscitation
- The effectiveness of interventions for which no evidence was available or for which evidence was insufficient to make treatment recommendations, including the following:
  - Use of a thermal mattress, which may assume greater importance if a parent is unable to provide skin-to-skin care

- Caps made of various materials
- Use of heated, humidified gases for assisted ventilation
- Early monitoring of temperature versus no early monitoring of temperature
- The role of low- or moderately low–cost interventions such as prewarmed bags of intravenous fluid placed around the newborn infant or prewarmed swaddling and clothing
- The effect of maternal hypothermia or hyperthermia on newborn infants' temperatures
- Standardising the timing and method of recording temperature for all newborn infants would enhance the potential both for benchmarking and for meta-analysis of studies in future reviews.

Suctioning Clear Amniotic Fluid at Birth (SysRev)

Rationale for Review

To support air breathing at birth, oropharyngeal and/or nasopharyngeal suctioning has been a widespread practice for newborn infants. The 2010 CoSTR[186] and many subsequent guidelines have recommended selective use of upper airway suctioning, with use only if the airway appears obstructed or positive pressure ventilation (PPV) is required, and there has been increasing concern that there may be adverse effects of routine upper airway suctioning. A Scoping Review (NLS 596) found sufficient evidence to justify a SysRev.[187] A SysRev was initiated from a priority list from the ILCOR NLS Task Force; PROSPERO registration CRD42021286258.[Fawke, 2022 ####] The full text of this review can be found on the ILCOR website.[188]

Population, Intervention, Comparator, Outcome, Study Design, and Time Frame

- **Population:** Newborn infants who are born through clear (not meconium-stained) amniotic fluid
- **Intervention:** Initial suctioning of the mouth and nose
- **Comparator:** No initial suctioning
- **Outcome:**
  - Critical: Advanced resuscitation and stabilization interventions (intubation, chest compressions, epinephrine) in the delivery room
  - Important: Receipt of assisted ventilation; receipt and duration of oxygen supplementation; adverse effects of intervention (eg, apnea, bradycardia, injury, infection, low Apgar scores, dysrhythmia); unanticipated admission to the neonatal intensive care unit (NICU)[142]
- Study Design: RCTs and non-randomized studies (non-RCTs, interrupted time series, controlled before-and-after studies, and cohort studies) were eligible for inclusion. Unpublished studies, case series, and animal studies were excluded.
- **Time frame:** All years and all languages were included if an English abstract was available. Literature search was performed on September 21, 2021.

Consensus on Science

The SysRev identified 11 studies (9 RCTs including 1138 participants[189-197] and 2 observational studies[198,199]) for inclusion. The studies predominantly enrolled healthy, low-risk term newborn infants. For 2 of the RCTs[192,193] enrolling 280 participants, the task force had concerns about the reliability of the oxygen saturation and heart rate data. Therefore, results of

these studies have been excluded from the meta-analysis. In sensitivity analysis, exclusion of these studies did not change the overall outcome.

Data relating to the key critical and important outcomes for this comparison are summarized in Table 23. Evidence for additional outcomes that were evaluated is included in the full online CoSTR.[188]

Table 23. Suctioning Clear Amniotic Fluid at Birth

Outcomes (importance)	Participants (studies), n	Certainty of the evidence (GRADE)	RR (95% CI)	Anticipated absolute effects (n)	
				Risk with no suctioning	RD with suctioning
Assisted ventilation (important)	742 (3 RCTs) Bancalari et al,[189] 2019 Kelleher et al,[194] 2013 Modarres Nejad et al,[195] 2014	Very low	0.72 (0.40–1.31)	64 per 1000	18 fewer per 1000 (39 fewer–20 more)
Advanced resuscitation and stabilization interventions (important)	742 (3 RCTs) Bancalari et al,[189] 2019 Kelleher et al,[194] 2013 Modarres Nejad et al,[195] 2014	Very low	0.72 (0.40–1.31)	64 per 1000	18 fewer per 1000 (39 fewer–20 more)
Oxygen saturations at 5 min (important)	280 (3 RCTs) Bancalari et al,[189] 2019 Modarres Nejad et al,[195] 2014 Takahashi et al,[196] 2009	Very low	Not applicable	Mean oxygen saturation 84.2%	MD 0.26% lower (1.77% lower–1.26% higher)
HR at 5 min (important)	84 (1 RCT) Bancalari et al,[189] 2019	Very low	Not applicable	Mean HR 162/min without suctioning	MD 1.00/min lower (7.96/min lower–5.96/min higher)

GRADE indicates Grading of Recommendations Assessment, Development, and Evaluation; HR, heart rate; MD, mean difference; RCT, randomized controlled trial; RD, risk difference; and RR, risk ratio.

For all predefined subgroup analyses, there were insufficient data available.

Treatment Recommendations

We suggest that suctioning of clear amniotic fluid from the nose and mouth should not be used as a routine step for newborn infants at birth (weak recommendation, very low–certainty evidence).

Airway positioning and suctioning should be considered if airway obstruction is suspected (good practice statement).

Justification and Evidence-to-Decision Framework Highlights

The complete evidence-to-decision table is provided in Appendix A.

The NLS Task Force found no justification to routinely use an intervention such as oral and nasal suctioning in the absence of demonstrated benefit. The participants in the included studies were predominantly healthy, term newborn infants, and there could be potential for unmeasured harm if suctioning caused delay in resuscitation for those who require it.

This systematic review recommendation does not apply to situations where there are concerns regarding airway obstruction.

Task Force Knowledge Gaps

- The role of suctioning of clear amniotic fluid at birth for newborn infants who are at high risk of needing respiratory support or more advanced resuscitation
- The role of suctioning of clear amniotic fluid at birth for preterm newborn infants
- Adherence to guidelines in relation to suctioning of the upper airway

Tactile Stimulation for Resuscitation Immediately After Birth (SysRev)

Rationale for Review

Tactile stimulation has been included in the initial steps of stabilization of the newborn infant in the treatment recommendations from ILCOR in 1999, 2006, 2010, 2015, and 2020[139,186,187,200,201] largely based on expert opinion. Because the effectiveness of tactile stimulation to facilitate breathing at birth has never been systematically evaluated by ILCOR, this PICO question was prioritized by the NLS Task Force for SysRev (PROSPERO; registration CRD42021227768).[202] The full text of this CoSTR can be found on the ILCOR website.[203]

Population, Intervention, Comparator, Outcome, Study Design, and Time Frame

- **Population:** Term or preterm newborn infants immediately after birth with absent, intermittent, or shallow respirations.
- **Intervention:** Any tactile stimulation performed within 60 seconds after birth and defined as one or more of the following: rubbing the chest/sternum; rubbing the back; rubbing the soles of the feet; flicking the soles of the feet; combination of these methods. This intervention should be done in addition to routine handling with measures to maintain temperature.
- **Comparison**: Routine handling with measures to maintain temperature, defined as care taken soon after birth, including positioning, drying and additional thermal care.
- **Outcome:**
  - Critical: Survival as reported by authors; neurodevelopmental outcomes
  - Important: Establishment of spontaneous breathing without PPV (yes or no); time to the first spontaneous breath or crying from birth; time to heart rate 100/min or greater from birth; intraventricular hemorrhage (only in preterm infants <34 weeks' gestation); oxygen

and/or respiratory support at admission to a neonatal special or intensive care unit; admission to a neonatal special or intensive care unit for those not admitted by protocol based on gestational age and/or birthweight[142]

  - Potential subgroups were defined a priori: gestational age (<34 weeks', 34–36 6/7 weeks', and ≥37 weeks' gestation), cord management (early cord clamping, delayed cord clamping, and cord milking), clinical settings (high and low resource), and method of stimulation (type, number and/or duration of stimuli).

- **Study design:** RCTs and nonrandomized studies (non-RCTs, interrupted time series, controlled before-and-after studies, and cohort studies) were eligible for inclusion. Unpublished studies (conference abstracts, trial protocols) and animal studies were excluded.
- **Time frame:** All years and all languages were included if there was an English abstract. The literature search was first done on December 6, 2020, with final update on September 17, 2021.

Consensus on Science

The SysRev identified 2 observational studies.[204,205] The study by Baik-Schneditz et al was not eligible for data analysis because of its critical risk of bias (mainly because of confounding by indication).[204] Therefore, only the study by Dekker et al with 245 preterm newborn infants was analyzed (Table 24).[205]

Table 24. Tactile Stimulation for Resuscitation of Newborn Infants Immediately After Birth

Outcomes (importance)	Participants (studies), n	Certainty of the evidence (GRADE)	RR (95% CI)	Anticipated absolute effects (n)	
				Risk with routine handling only	RD with tactile stimulation in addition to routine handling
Tracheal intubation in delivery room (important)	245 (1 observational study) Dekker et al,[205] 2018	Very low	0.41 (0.20–0.85)	177 per 1000	105 fewer per 1000 infants (142 fewer–27 fewer) were intubated when tactile stimulation was used

GRADE indicates Grading of Recommendations Assessment, Development, and Evaluation; RD, risk difference; and RR, risk ratio.

No data were reported on other prespecified outcomes or by subgroups.

Treatment Recommendations

We suggest it is reasonable to apply tactile stimulation in addition to routine handling with measures to maintain temperature in newborn infants with absent, intermittent, or shallow respirations during resuscitation immediately after birth (weak recommendation, very low–certainty evidence).

Tactile stimulation should not delay the initiation of PPV for newborn infants who continue to have absent, intermittent, or shallow respirations after birth (good practice statement).

Justification and Evidence-to-Decision Framework Highlights

The complete evidence-to-decision table is provided in Appendix A.

The NLS Task Force based the treatment recommendation on several inferences. The very limited available data suggest a possible benefit to tactile stimulation in decreasing the need for tracheal intubation in preterm infants, but the certainty of evidence is very low. The results of the single study identified should be analyzed with caution because of indirectness (all 245

infants were put on CPAP before tactile stimulation, in contrast to the common practice of tactile stimulation before CPAP or PPV), possible selection bias (among 673 infants who were video-recorded immediately after birth, 245 (36%) were included in the study), and confounding (the clinical indication of tactile stimulation was retrospectively assessed and it could not be determined in 34% of the 585 tactile stimulation episodes). Additional observational studies showed that, in general, infants who received tactile stimulation responded with crying, grimacing, and body movements, although the methods of stimulation were variable and the outcomes analyzed were not exactly the same among the studies.[206-209] These studies could not be included in the SysRev because of the lack of control groups who did not receive tactile stimulation.

A single-center RCT compared single versus repetitive tactile stimulation in newborn preterm infants immediately after birth. Patients in the repetitive stimulation group had higher oxygen saturation levels and lower oxygen requirements at the start of transport to the NICU. This study could not be included in the SysRev because of the lack of control group who did not receive tactile stimulation. A single-center RCT compared back rubbing to foot flicking to provide tactile stimulation in preterm and term infants with birthweight greater than 1500g who did not cry at birth. There was no difference between both techniques in achieving effective crying to prevent the need for PPV.[210] This study could not be included in the SysRev because of the lack of a control group that did not receive tactile stimulation.

In studies that analyze a bundle of procedures to stimulate respiratory transition at birth in low-resource settings, tactile stimulation, together with upper airway suction, triggered the initiation of spontaneous respirations.[211,212] These studies could not be included in the SysRev

because of the inability to isolate the effects of tactile stimulation as well as the lack of a control group.

Despite the possible benefits outlined above, there are some concerns related to possible adverse effects of tactile stimulation in delaying the initiation of ventilation beyond 60 seconds after birth, which may then compromise the efficacy of the overall resuscitation.[208,210,213] In addition, there is a report of soft tissue trauma after tactile stimulation.[214]

Task Force Knowledge Gaps

For full list, see the complete CoSTR.[203]

- Effect of tactile stimulation on the main outcomes: breathing without PPV; time to the first spontaneous breath or crying from birth; and time to heart rate 100/min or greater from birth
- Effect of tactile stimulation on secondary outcomes: death in the delivery room, hospital death; neurodevelopmental outcomes; intraventricular hemorrhage only in preterm infants; oxygen and/or respiratory support at admission to a neonatal special unit or intensive care unit; and admission to a neonatal special or intensive care unit for those not admitted by protocol
- Effects of tactile stimulation in different gestational ages and with different cord management strategies
- Which patients benefit from tactile stimulation (all, patients with apnea, irregular breathing, or other)
- Indications for tactile stimulation
- Efficacy of different methods of tactile stimulation (rubbing, flicking, or other) and locations on the body
- Optimal duration and number of each stimulus

Delivery Room Heart Rate Monitoring to Improve Outcomes for Newborn Infants (SysRev)

Rationale for Review

Monitoring heart rate in the first minutes after birth was last reviewed by the NLS Task Force in 2015, at which time the focus was on which methods resulted in the most accurate measurement at the earliest time.[139] This SysRev focused on critical and important patient outcomes and was initiated from a priority list from the ILCOR NLS Task Force; PROSPERO; registration CRD42021283438. [Kawakami, 2022 ####] The full text of this review can be found on the ILCOR website.[215]

Population, Intervention, Comparator, Outcome, Study Design, and Time Frame

- **Population:** Newborn infants in the delivery room
- **Intervention:** Use of electrocardiogram (ECG), Doppler device, digital stethoscope, photoplethysmography, video plethysmography, dry electrode technology, or any other newer modalities
- **Comparator:** 1) Pulse oximeter with or without auscultation; 2) auscultation alone; 3) between intervention comparison
- **Outcome:**
  - Critical: Chest compressions or epinephrine (adrenaline) administration; death before hospital discharge
  - Important: Duration of PPV; tracheal intubation; time from birth to heart rate 100/min or greater as measured by ECG; resuscitation team performance; unanticipated admission to the NICU.[142]

- **Study design:** RCTs and non-randomized studies (non-RCTs, interrupted time series, controlled before-and-after studies, and cohort studies) were eligible for inclusion. Unpublished studies and case series were excluded.
- **Time frame:** All years and all languages were included if there was an English abstract. The literature search was performed on October 29, 2021.

Consensus on Science

Comparison 1: ECG Versus Auscultation Plus Pulse Oximeter During Resuscitation of Newborn Infants

The SysRev identified 2 RCTs[216,217] involving 91 newborn infants and 1 cohort study[218] involving 632 newborn infants.

Data relating to the key critical and important outcomes for this comparison are summarized in Table 25. Evidence for additional outcomes evaluated is included in the full online CoSTR.[215]

Table 25. ECG Versus Auscultation Plus Pulse Oximeter During Resuscitation of Newborn Infants

Outcomes (importance)	Participants (studies), n	Certainty of the evidence (GRADE)	RR (95% CI)	Anticipated absolute effects(n)	
				Risk with auscultation plus pulse oximeter	RD with use of ECG plus auscultation plus pulse oximeter
Duration of PPV (important)	51 (1 RCT) Abbey et al,[216] 2021	Very low	N/A	Mean duration of PPV 196 s	MD 91 s shorter (78 s shorter–36 s longer) with addition of ECG
Tracheal intubation (important)	91 (2 RCTs) Abbey et al,[216] 2021 Katheria et al,[217] 2017	Low	1.34 (0.69–2.59)	244 per 1000	81 more infants per 1000 were intubated in the DR (74 fewer–384 more) with the addition of ECG

Outcomes (importance)	Participants (studies), n	Certainty of the evidence (GRADE)	RR (95% CI)	Anticipated absolute effects(n)	
				Risk with auscultation plus pulse oximeter	RD with use of ECG plus auscultation plus pulse oximeter
Tracheal intubation (important)	632 (1 observational study) Shah et al,[218] 2019	Low	0.75 (0.62–0.90)	475 per 1000	119 fewer infants per 1000 were intubated in the DR (181 fewer–48 fewer) with the addition of ECG
Chest compressions (important)	632 (1 observational study) Shah et al,[218] 2019	Low	2.14 (0.98–4.70)	30 per 1000	35 more infants per 1000 received chest compressions (1 fewer–113 more) received chest compressions) with the addition of ECG
Epinephrine (adrenaline) (critical)	632 (1 observational study) Shah et al,[218] 2019	Low	3.56 (0.42–30.3)	4 per 1000	10 more infants per 1000 received epinephrine (2 fewer–111 more) with the addition of ECG
Death before discharge (critical)	51 (1 RCT) Abbey et al,[216] 2021	Very low	0.96 (0.15–6.31)	77 per 1000	3 fewer infants per 1000 died (74 fewer–462 more) with the addition of ECG
Death before discharge (critical)	632 (1 observational study) Shah et al,[218] 2019	Low	0.96 (0.57–1.61)	87 per 1000	3 fewer infants per 1000 died (38 fewer–53 more) with the addition of ECG

GRADE indicates Grading of Recommendations Assessment, Development, and Evaluation; ECG, electrocardiogram; DR, delivery room; MD, mean difference; RCT, randomized controlled trial; RD, risk difference; and RR, risk ratio.

No studies were found that provided outcomes relevant to this SysRev for other modalities versus pulse oximetry and/or auscultation (Comparison 2) or for between-intervention comparisons (Comparison 3).

Treatment Recommendations

Where resources permit, we suggest that the use of ECG for heart rate assessment of a newborn infant requiring resuscitation in the delivery room is reasonable (weak recommendation, low-certainty 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 evidence).

There is insufficient evidence to make a treatment recommendation regarding the use of a digital stethoscope, audible or visible Doppler ultrasound, dry electrode technology, reflectance-mode green light photoplethysmography, 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 (good practice statement).

Justification and Evidence-to-Decision Framework Highlights

The evidence-to-decision table is provided in Appendix A.

The treatment recommendations were informed by low-certainty evidence that, for most outcomes, did not demonstrate improvement or suggestion of harm for any critical or important outcome. The only exception was a lower proportion of infants intubated in the delivery room in an observational study,[218] a result that was not confirmed in the meta-analysis of 2 RCTs.[216,217] The potential advantages of rapid signal acquisition and continuous, accurate heart rate monitoring need to be weighed against the potential costs of equipment and training.

Task Force Knowledge Gaps

- Higher-certainty evidence regarding whether ECG or other modalities for heart rate assessment improve critical and important neonatal outcomes
- Impact of ECG or other modalities for heart rate measurement on resuscitation team performance
- Impact of ECG and other modalities for heart rate assessment on equity
- Cost-effectiveness of different modalities for heart rate assessment in the delivery room
- Whether the utility of various modalities varies by subgroups, including vigorous versus nonvigorous newborn infants, those who do or don't require tracheal intubation or more advanced resuscitation, by gestational age and weight, by method of umbilical cord management, and for pulseless electrical activity

CPAP Versus No CPAP for Term Respiratory Distress in the Delivery Room (SysRev)

Rationale for Review

CPAP has been included in the neonatal resuscitation algorithm to help infants with persistently labored breathing or cyanosis after the initial steps of resuscitation. For spontaneously breathing preterm newborn infants with respiratory distress requiring respiratory support in the delivery room, ILCOR has suggested initial use of CPAP rather than tracheal intubation and intermittent PPV.[187] Although it has become increasingly frequent to provide CPAP in the delivery room for late preterm and term infants, this practice has not been systematically evaluated by ILCOR and therefore this PICO was prioritized by the NLS Task Force (PROSPERO; registration CRD42021225812).[Shah, 2022 ####]

The full text of this CoSTR can be found on the ILCOR website.[219]

Population, Intervention, Comparator, Outcome, Study Design, and Time Frame

- **Population:** In spontaneously breathing newly born ≥34 weeks' gestation newborn infants with respiratory distress and/or low oxygen saturations during transition after birth
- **Intervention:** CPAP at different levels with or without supplemental oxygen
- **Comparison**: No CPAP with or without supplemental oxygen
- **Outcome:**
  - Critical: Chest compressions in the delivery room; death at hospital discharge; moderate to severe neurodevelopmental impairment (>18 months)
  - Important: Admissions to the NICU or higher level of care; receiving any positive pressure support in the NICU; receiving tracheal intubation in the delivery room; use and duration of respiratory support in NICU; air-leak syndromes including pneumothorax and pneumomediastinum; length of hospital stay[142]
- **Study design:** RCTs and nonrandomized studies (non-RCTs, interrupted time series, controlled before-and-after studies, cohort studies, and simulation studies) were eligible for inclusion. Unpublished studies (eg, conference abstracts, trial protocols) and animal studies were excluded.
- **Time frame:** All years and all languages were included if an English abstract was available. The literature search was first performed on November 30, 2020, and updated on October 11, 2021.

Consensus on Science

The SysRev identified 2 RCTs[220,221] involving 323 newborn infants and 2 observational studies, 1 of which was divided in 2 publications[222-224], involving 8476 infants. Relevant data

from the author via electronic communications have been collated into 1 study for purpose of this meta-analysis.[222,223] Meta-analysis of RCT evidence is shown in Table 26. No evidence was identified for tracheal intubation, need for chest compressions in the delivery room and neurodevelopmental impairment.

Table 26. CPAP at Different Levels With or Without Supplemental Oxygen Versus No CPAP With or Without Supplemental Oxygen for Respiratory Distress in the Delivery Room for Late Preterm and Term Newborn Infants

Outcomes (importance)	Participants (studies), n	Certainty of the evidence (GRADE)	RR (95% CI)	Anticipated absolute effects (n)	
				Risk with no CPAP provided for respiratory distress in the DR	RD with CPAP provided for respiratory distress in the DR
NICU admissions (important)	323 (2 RCTs) Celebi et al,[220] 2016 Osman et al,[221] 2019	Very low	0.28 (0.11–0.67)	129 per 1000	94 fewer per 1000 late preterm and term newborn infants (115 fewer–44 fewer) were admitted to the NICU when CPAP was used
Air-leak syndromes (important)	8476 (3 observational studies) Hishikawa et al,[223] 2015 Hishikawa et al,[222] 2016 Smithhart et al,[224] 2019	Very low	4.92 (4.13–5.87)	34 per 1000	133 more per 1000 late preterm and term newborn infants (106 more–166 more) developed air-leak syndrome when CPAP was used
NICU respiratory support (important)	323 (2 RCTs) Celebi et al,[220] 2016 Osman et al,[221] 2019	Very low	0.18 (0.06–0.6)	97 per 1000	79 fewer per 1000 late preterm and term newborn infants (91 fewer–39 fewer) needed NICU respiratory support when CPAP was used
Death before discharge from hospital (critical)	323 (2 RCTs) Celebi et al,[220] 2016 Osman et al,[221] 2019	Very low	0.30 (0.01–6.99)	6 per 1000	5 fewer per 1000 late preterm and term newborn infants (6 fewer–39 more) died before discharge from the hospital when CPAP was used

CPAP indicates continuous positive airway pressure; DR, delivery room; GRADE, Grading of Recommendations Assessment, Development, and Evaluation; NICU, neonatal intensive care unit; PPV, positive pressure ventilation; RCT, randomized controlled trial; RD, risk difference; and RR, risk ratio.

Treatment Recommendations

For spontaneously breathing late preterm and term newborn infants in the delivery room with respiratory distress, there is insufficient evidence to suggest for or against routine use of CPAP compared with no CPAP.

Justification and Evidence-to-Decision Framework Highlights

The evidence-to-decision table is provided in Appendix A.

In making this recommendation, the NLS Task Force acknowledges that the use of CPAP in the delivery room has been recommended for infants with persistent signs of respiratory distress, labored breathing, or cyanosis after the initial steps of resuscitation. This was mainly extrapolated from evidence in preterm patients. The benefits and risks in late preterm and term newborn infants had not been systematically reviewed before this review. The 2 RCTs included only 323 subjects, who were all delivered by cesarean section.[220,221] One RCT enrolled 259 newborns and used prophylactic CPAP.[220] Within the observational studies, a positive association between the use of CPAP and the presence of air-leak syndromes was identified (1 nested cohort study included only newborn infants admitted to the NICU). Therefore, in concluding that no recommendation could be made, the task force integrated the values placed on avoidance of potential harm, as noted by the positive association between CPAP use and air-leak syndromes, and potential benefit, as noted by the reduction in NICU admission among infants born by cesarean section.

Knowledge Gaps

- Large multicenter RCTs evaluating the effect of delivery room CPAP for late preterm and term newborns with respiratory distress are needed.

- The effect of CPAP in the delivery room for late preterm and term infants delivered vaginally
- The impact of labor on outcomes when CPAP is used for respiratory distress in the delivery room
- The effect of CPAP among different populations: late preterm versus term and post-term newborn infants
- The effect of CPAP after any previous positive pressure support (PPV or sustained inflation)
- Whether effects of CPAP differ with or without the use of supplemental oxygen
- The effect of the modes of support: interfaces (facemask versus nasal prongs, cannula versus alternative airway), devices (T-piece versus flow-inflating bag); and level of CPAP support: high CPAP (>6 cm H_2O) versus low CPAP (4–6 cm H_2O).

Supraglottic Airways for Neonatal Resuscitation (SysRev)

Rationale for Review

Given the importance of effective PPV for resuscitation of newborn infants and the limitations of using either a face mask or endotracheal tube, the NLS Task Force prioritized evaluation of SGAs for PPV. In 2015, the NLS Task Force conducted a SysRev focused on using an SGA compared with endotracheal intubation as the secondary device for PPV if initial ventilation with a face mask failed. For this review, the task force aimed to compare the use of an SGA with a face mask as the initial device for administering PPV during resuscitation immediately after birth and to determine if use of an SGA would decrease the probability of failing to improve with initial PPV. Additional randomized trials comparing an SGA with a face mask as the initial device for PPV have been published since the previous review. Thus, a SysRev was undertaken (PROSPERO; registration CRD42021230722). [Yamada, 2022 ####]

The full text of this CoSTR can be found on the ILCOR website.[225]

Population, Intervention, Comparator, Outcome, Study Design, and Time Frame

- **Population:** Newborn infants 34 0/7 weeks' or more gestation receiving intermittent PPV during resuscitation immediately after birth
- **Intervention:** SGA
- **Comparator:** Face mask
- **Outcome:**
  - Critical: Chest compressions or epinephrine (adrenaline) administration during initial resuscitation; survival to hospital discharge; neurodevelopmental impairment at 18 months of age or older (abnormal motor, sensory, or cognitive function or low educational achievement at ≥18 months of age using an appropriate, standardized test or examination)
  - Important: Failure to improve with the device; tracheal intubation during initial resuscitation; time to heart rate greater than 100/min during initial resuscitation; duration of PPV during initial resuscitation; time to cessation of PPV; soft tissue injury (as defined by authors); admission to the NICU; air leak during the initial hospital stay (presence of pneumothorax, pneumomediastinum, pulmonary interstitial emphysema, or pneumopericardium) [142]

    Potential subgroups (late preterm vs term and cuffless vs cuffed supraglottic airway) were defined a priori.

- **Study design:** RCTs, quasi-RCTs, and nonrandomized studies (non-RCTs, interrupted time series, controlled before-and-after studies, cohort studies) were eligible for inclusion. Quasi-RCTs were included with RCTs in meta-analyses. Unpublished studies (eg, conference

abstracts, trial protocols) were excluded. Outcomes from observational studies were assessed if there were fewer than 2 included RCTs/quasi-RCTs or if the certainty of evidence from RCTs/quasi-RCTs was scored very low.

- **Time frame:** All years and all languages were included if there was an English abstract. The literature search was updated to December 9, 2021.

Consensus on Science

The SysRev identified 5 RCTs[226-230] and 1 quasi-RCT[231] involving a total of 1857 newborn infants, and 2 retrospective cohort studies[232,233] involving 218 newborn infants. An additional study[234] reported secondary outcomes from a subset of newborn infants enrolled in an included RCT.[227] Meta-analysis results are shown in Table 27. For additional outcomes please see the full CoSTR.[225]

Table 27. Meta-analysis of RCTs for SGA Compared With Face Mask for PPV During Resuscitation Immediately After Birth

Outcomes (importance)	Participants (studies), n	Certainty of the evidence (GRADE)	RR (95% CI)	Anticipated absolute effects (n)	
				Risk with face mask	RD with SGA
Failure to improve with device (important)	1823 (6 RCTs) Feroze et al,[226] 2008 Pejovic et al,[227] 2020 Pejovic et al,[228] 2018 Singh et al,[229] 2005 Trevisanuto et al,[230] 2015 Zhu et al, [231] 2011	Moderate	0.24 (0.17–0.36)	138 per 1000	105 fewer per 1000 infants (114 fewer–88 fewer) had failure to improve when an SGA was used
Endotracheal intubation during resuscitation (important)	1715 (4 RCTs) Pejovic et al,[227] 2020 Singh et al,[229] 2005 Trevisanuto et al,[230] 2015 Zhu et al,[231] 2011	Low	0.34 (0.20–0.56)	62 per 1000	41 fewer per 1000 infants (49 fewer–27 fewer) had endotracheal intubation during resuscitation when an SGA was used
Chest compressions during resuscitation (critical)	1346 (3 RCTs) Pejovic et al,[227] 2020 Singh et al,[229] 2005	Low	0.97 (0.56–1.65)	39 per 1000	1 fewer per 1000 infants (17 fewer–26 more) had chest compressions

Outcomes (importance)	Participants (studies), n	Certainty of the evidence (GRADE)	RR (95% CI)	Anticipated absolute effects (n)	
				Risk with face mask	RD with SGA
	Trevisanuto et al,[230] 2015				during resuscitation when an SGA was used
Epinephrine (adrenaline) administration during resuscitation (critical)	192 (2 RCTs) Singh et al, 2005[229] Trevisanuto et al,[230] 2015	Low	0.67 (0.11–3.87)	31 per 1000	10 fewer per 1000 infants (28 fewer–90 more) had epinephrine (adrenaline) administration during resuscitation when an SGA was used
Time to heart rate >100/min (important)	46 (1 RCT) Pejovic et al,[234] 2021	Low		The mean time was 78 s	MD 66 s lower (31 s lower–100 s lower) when an SGA was used
Duration of PPV (important)	610 (4 RCTs) Pejovic et al,[228] 2018 Singh et al,[229] 2005 Trevisanuto et al,[230] 2015 Zhu et al, [231] 2011	Low	NA	The mean time was 62 s	MD 18 s lower (24 s lower–36 s lower) when an SGA was used
Admission to neonatal intensive care (important)	1314 (4 RCTs) Pejovic et al,[227] 2020 Pejovic et al,[228] 2018 Singh et al,[229] 2005 Trevisanuto et al, [230] 2015	Very low	0.97 (0.94–1.00)	847 per 1000	25 fewer per 1000 infants (51 fewer–0 fewer) when an SGA was used
Air leak (important)	192 (2 RCTs) Singh et al, 2005[229] Trevisanuto et al, 2015[230]	Very low	Not estimable (no events)	0 per 1000	0 fewer per 1000 infants (30 fewer–30 more) when an SGA was used
Soft tissue injury (important)	1724 (4 RCTs) Pejovic et al, 2020[227] Singh et al, 2005[229] Trevisanuto et al, 2015[230] Zhu et al, 2011[231]	Low	1.05 (0.15–7.46)	2 per 1000	0 fewer per 1000 infants (2 fewer–15 more) when an SGA was used
Survival to hospital discharge (critical)	50 (1 RCT) Singh et al,[229] 2005	Low	1.00 (0.93–1.08)	1000 per 1000	0 fewer per 1000 infants (40 fewer–20 more) when an SGA was used

GRADE indicates Grading of Recommendations Assessment, Development, and Evaluation; NA, not applicable; NICU, neonatal intensive care unit; PPV, positive pressure ventilation; RCT, randomized controlled trial; RD, risk difference; MD, mean difference; RR, risk ratio; and SGA, supraglottic airway.

Subgroup Analyses

No data were reported to perform prespecified subgroup analyses by gestational age (term versus late preterm). For the planned subgroup analysis based on device design (i-Gel™ versus other device), failure to improve with the device was the only outcome with sufficient data to analyze, and there was no evidence of an interaction (P= 0.29, I_2=10%).

Treatment Recommendations

Where resources and training permit, we suggest that a supraglottic airway may be used in place of a face mask for newborn infants 34 0/7 weeks' or more gestation receiving intermittent positive pressure ventilation during resuscitation immediately after birth (weak recommendation, low-certainty evidence).

Justification and Evidence-to-Decision Framework Highlights

The evidence-to-decision table is provided in Appendix A.

In making these recommendations, the NLS Task Force acknowledged several issues. SGAs compared with face masks may be more effective in achieving successful resuscitation of late preterm and term newborn infants who receive PPV immediately after birth. Although *failure to improve with device* was variously defined by authors and often included cross-over to the alternative device, there was a strong inverse association between the use of an SGA and risk of tracheal intubation. This may reflect a greater likelihood of achieving effective ventilation with use of an SGA. Nevertheless, given that the interventions were not blinded and the ability to intubate in the largest trial was dependent on physician availability, there are risks of differential co-interventions and other biases. Furthermore, optimal information size was not achieved for any of the critical or important prespecified outcomes except duration of PPV. Consequently,

further trials are needed before stronger recommendations can be made about use of SGAs as the initial device for PPV.

Balancing factors in the task force recommendation include the training required for SGA insertion and the safety of the SGA compared with face mask ventilation. Although the training provided was incompletely documented in several studies[226,229,231] and no study compared the effectiveness of different training programs, the success rate for insertion was high despite apparently short-duration training with a manikin. In the largest trial,[227] participating midwives received brief didactic training for insertion of a cuffless supraglottic device as part of a Helping Babies Breathe course and were required to demonstrate 3 successful insertions in a manikin before participating in the study. Only 2 RCTs[229,230] indicated that successful insertion in a newborn infant was a prerequisite to study participation. Although the individual studies had limited power to establish the safety of the SGA, the task force was encouraged by the relatively large number of newborn infants reported across all studies and the small number of adverse events.

Costs and cost-effectiveness have not been studied. In 4 of the included studies[227,228,230,231] the authors indicated that the device was provided as part of the study. The availability of resources and economic considerations will influence decisions regarding use of an SGA or face mask. Given the large number of infants worldwide who receive PPV after birth, it is important to evaluate the cost-effectiveness of the SGA as the initial device for PPV.

Task Force Knowledge Gaps

For a complete list, please see the online CoSTR.[225]

- Training requirements to achieve and maintain competency with SGA insertion, including different types of devices

- Effectiveness and safety of SGAs as the initial device for PPV in high-resource settings
- Effectiveness and safety of SGAs compared with face masks during chest compressions
- Effectiveness and safety of different SGA designs
- Effectiveness and safety of SGAs for PPV among newborn infants less than 34 weeks' gestation

Respiratory Function Monitoring During Neonatal Resuscitation at Birth (SysRev)

Rationale for Review

Respiratory function monitors (RFMs) have the potential to improve the outcomes of assisted ventilation during resuscitation of newborn infants by helping resuscitation teams avoid excessive (harmful to the lungs and brain) or insufficient (ineffective) tidal volumes during resuscitation. Inappropriate tidal volumes can be caused by mask leak, airway obstruction, or ventilation pressures that are too high or too low for the mechanical characteristics of the individual infant's lungs. A SysRev conducted for ILCOR in 2015[139] found only 1 small eligible study.[235] Because the NLS Task Force was aware that further studies had been published, a SysRev was prioritized (PROSPERO; registration CRD42021278169).[Fuerch, 2022 ####] The full text of this review can be found on the ILCOR website.[236]

Population, Intervention, Comparator, Outcome, Study Design, and Time Frame

- **Population:** Newborn infants receiving respiratory support at birth
- **Intervention:** Display of an RFM
- **Comparator:** No display of an RFM
- **Outcome:**
  - Critical: Death before discharge, severe intraventricular hemorrhage

  - Important: Response to and characteristics of the resuscitation; achieving desired tidal volumes; percentage maximum mask leak; intubation in the delivery room; pneumothorax; bronchopulmonary dysplasia; duration of respiratory support during neonatal intensive care[142]

- **Study design:** RCTs, quasi-RCTs, and non-randomized studies (non-RCTs, interrupted time series, controlled before-and-after studies, cohort studies) were eligible for inclusion. Unpublished studies were excluded.
- **Time frame:** All years and all languages were included if there was an English abstract. The literature search was updated to December 31, 2021.

Consensus on Science

The SysRev identified 3 RCTs,[235,237,238] involving 443 newborns.

Data relating to the key critical and important outcomes for this comparison are summarized in Table 28. Evidence for additional outcomes evaluated is included in the full online CoSTR.[236]

Table 28. Use of an RFM During Neonatal Resuscitation at Birth

Outcomes (importance)	Participants (studies), n	Certainty of the evidence (GRADE)	RR (95% CI)	Anticipated absolute effects (n)	
				Risk with standard care	RD with use of standard care plus an RFM
Tracheal intubation in the delivery room (important)	443 (3 RCTs) Schmölzer et al,[235] 2012 Van Zanten et al,[237] 2021 Zeballos Sarrato et al,[238] 2019	Very low	0.90 (0.55–1.48)	353 per 1000	40 fewer infants per 1000 (220 fewer–130 more) were intubated in the DR when an RFM was used
Achieving desired tidal volumes (important)	337 (2 RCTs) Schmölzer et al,[235] 2012 Van Zanten et al,[237] 2021	Low	0.96 (0.69–1.34)	301 per 1000	10 fewer infants per 1000 (110 fewer–80 more) achieved the desired tidal volume in

Outcomes (importance)	Participants (studies), n	Certainty of the evidence (GRADE)	RR (95% CI)	Anticipated absolute effects (n)	
				Risk with standard care	RD with use of standard care plus an RFM
					the DR when an RFM was used
Pneumothorax (important)	393 (2 RCTs) Van Zanten et al,[237] 2021 Zeballos Sarrato et al,[238] 2019	Low	0.54 (0.26–1.13)	94 per 1000	40 fewer infants per 1000 (90 fewer–10 more) had a pneumothorax when an RFM was used
Death before hospital discharge (critical)	442 (3 RCTs) Schmölzer et al,[235] 2012 Van Zanten et al,[237] 2021 Zeballos Sarrato et al, 2019[238]	Low	1.00 (0.66–1.52)	165 per 1000	0 fewer infants per 1000 (70 fewer–70 more) died when an RFM was used
Severe IVH (critical)	287 (1 RCT) Van Zanten et al,[237] 2021	Low	0.96 (0.38–2.42	60 per 1000	0 fewer infants per 1000 (60 fewer–50 more) developed severe IVH when an RFM was used
IVH (all grades) (important)	393 (2 RCTs) Van Zanten et al,[237] 2021 Zeballos Sarrato et al,[238] 2019	Low	0.69 (0.49–0.96)	318 per 1000	100 fewer infants per 1000 (180 fewer–10 fewer) developed IVH (all grades) when an RFM was used
BPD (important)	393 (2 RCTs) Van Zanten et al,[237] 2021 Zeballos Sarrato et al,[238] 2019	Low	0.85 (0.7–1.04)	527 per 1000	80 fewer infants per 1000 (180 fewer–20 more) developed BPD when an RFM was used

BPD indicates bronchopulmonary dysplasia; DR, delivery room; GRADE; Grading of Recommendations Assessment, Development, and Evaluation; IVH, intraventricular hemorrhage; PPV, positive pressure ventilation; RCT, randomized controlled trial; RD, risk difference, RFM, respiratory function monitor; and RR, risk ratio.

Treatment Recommendations

There is insufficient evidence to make a recommendation for or against the use of a respiratory function monitor in newborn infants receiving respiratory support at birth (low-certainty evidence).

Justification and Evidence-to-Decision Framework Highlights

The NLS Task Force concluded that a treatment recommendation could not be made because there was low confidence in effect estimates, and most could not rule out either clinical benefit or harm. Although intraventricular hemorrhage (all grades) was significantly reduced, there was no effect demonstrated for severe intraventricular hemorrhage. The finding had low certainty, was one of numerous secondary outcomes for the study that most influenced the pooled difference, and was the only finding of the study that suggested benefit of RFM use.[237] Information on costs of purchasing RFM devices and of training in their use was not available but would need to be justified by evidence of improvement in outcomes.

Task Force Knowledge Gaps

- Human factor assessment (eg, the design of RFM displays to ensure teams can make best use of displayed data during resuscitation, without distraction from other critical tasks)
- Development of low-cost devices for use in lower-resourced settings
- Training requirements to achieve and maintain competency in the acquisition and accurate interpretation of data derived from RFM during neonatal resuscitation
- Cost-effectiveness for the use of RFM (versus no RFM) during neonatal resuscitation
- Standardized definitions of respiratory function outcomes (eg, what comprises clinically significant mask leak or optimal versus suboptimal tidal ventilation during resuscitation)