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2023 American Heart Association and American Academy of Pediatrics Focused Update on Neonatal Resuscitation: An Update to the American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care

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AHA/AAP FOCUSED UPDATE

2023 American Heart Association and American Academy of Pediatrics Focused Update on Neonatal Resuscitation: An Update to the American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care

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ABSTRACT: This 2023 focused update to the neonatal resuscitation guidelines is based on 4 systematic reviews recently completed under the direction of the International Liaison Committee on Resuscitation Neonatal Life Support Task Force. Systematic reviewers and content experts from this task force performed comprehensive reviews of the scientific literature on umbilical cord management in preterm, late preterm, and term newborn infants, and the optimal devices and interfaces used for administering positive-pressure ventilation during resuscitation of newborn infants. These recommendations provide new guidance on the use of intact umbilical cord milking, device selection for administering positive-pressure ventilation, and an additional primary interface for administering positive-pressure ventilation.

Key Words: AHA Scientific Statements ■ infant ■ infant, newborn ■ intermittent positive-pressure ventilation ■ laryngeal masks ■ respiration, artificial ■ umbilical cord clamping ■ umbilical cord milking

TOP 10 TAKE-HOME MESSAGES FOR NEONATAL RESUSCITATION

1. For term and late preterm newborn infants ≥34 weeks' gestation who do not require resuscitation, delayed cord clamping (≥30 seconds) can be beneficial compared with early cord clamping (<30 seconds).
2. For term and late preterm newborn infants ≥34 weeks' gestation who do not require resuscitation, intact cord milking is not known to be beneficial compared with delayed cord clamping (≥30 seconds).
3. For nonvigorous term and late preterm newborn infants (35–42 weeks' gestation), intact cord milking may be reasonable compared with early cord clamping (<30 seconds).
4. For preterm newborn infants <34 weeks' gestation who do not require resuscitation, delaying cord clamping (≥30 seconds) can be beneficial compared with early cord clamping (<30 seconds).
5. For preterm newborn infants between 28 and 34 weeks' gestation who do not require resuscitation and in whom delayed cord clamping cannot be performed, intact cord milking may be reasonable.
6. For preterm newborn infants <28 weeks' gestation, intact cord milking is not recommended.
7. Effective positive-pressure ventilation is the priority in newborn infants who need support after birth.
8. Using a T-piece resuscitator to deliver positive-pressure ventilation is preferred to the use of a self-inflating bag.
9. Because both T-piece resuscitators and flow-inflating bags require a compressed gas source to function, a self-inflating bag should be available as a backup in the event of compressed gas failure when using either of these

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devices.

10. Use of a supraglottic airway may be considered as the primary interface to administer positive-pressure ventilation instead of a face mask for newborn infants delivered at ≥34 0/7 weeks' gestation.

Abbreviations

AAP	American Academy of Pediatrics
AHA	American Heart Association
COR	class of recommendation
DCC	delayed cord clamping
ILCOR	International Liaison Committee on Resuscitation
LOE	level of evidence
PPV	positive-pressure ventilation
RCT	randomized controlled trial

1. INTRODUCTION

Scope of the Guidelines

These guidelines are designed for North American health care practitioners caring for newborn infants who are looking for an up-to-date summary for clinical care, and for those who are seeking more in-depth information on these topics in resuscitation science and the gaps in current knowledge. This focused update is based on the systematic reviews of umbilical cord management in term and late preterm infants[1] and preterm infants,[2] and the devices and interfaces for administering positive-pressure ventilation (PPV).[3,4] The findings of those systematic reviews are also reported in the "2021 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations"[5] and the "2022 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations"[6] from the International Liaison Committee on Resuscitation (ILCOR). The guidelines contained in this document serve as an update on these topics from the "2020 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care"[7] and "Neonatal Life Support: 2020 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations" from the ILCOR Neonatal Life Support Task Force.[8]

Organization of the Writing Group

The Neonatal Life Support writing group includes neonatal physicians and nurses with backgrounds in clinical medicine, education, research, and public health. Volunteers with recognized expertise in neonatal resuscitation are nominated by the writing group co-chairs. Writing group members were selected by the American Heart Association (AHA) Emergency

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Cardiovascular Care Science Subcommittee and the American Academy of Pediatrics (AAP) Executive Board and then approved by the AHA Manuscript Oversight Committee.

The AHA and the AAP have rigorous conflict of interest policies and procedures to minimize the risk of bias or improper influence during the development of guidelines. Before their appointment, writing group members disclosed all relevant commercial relationships and other potential (including intellectual) conflicts. Writing group members whose research led to changes in guidelines were required to declare those conflicts during discussions and abstain from voting on those specific recommendations. These procedures are described more fully in "Part 2: Evidence Evaluation and Guidelines Development" of the 2020 guidelines.[9]

Appendix 1 of this document lists disclosure information and the writing group members' relevant relationships with industry.

Methodology and Evidence Review

Updated AHA/AAP guidelines for cardiopulmonary resuscitation and emergency cardiovascular care are developed in concert with ILCOR's continuous evaluation of new resuscitation science.[9] This 2023 focused update is based on 4 systematic reviews completed by the ILCOR Neonatal Life Support Task Force, which reviewed the science on umbilical cord management in preterm, late preterm, and term newborn infants[1,2] and on devices and interfaces for administering PPV for newborn infants.[3,4] The ILCOR Neonatal Life Support Task Force used the findings of these systematic reviews to draft treatment recommendations, which were posted online for public comment. The final wording has been published in the Consensus on Science With Treatment Recommendations summary documents from 2021 and 2022.[5,6] Full details on the ILCOR systematic review process can be found in the 2022 publication.[6] For this 2023 focused update, the Neonatal Life Support writing group analyzed and discussed the systematic reviews, carefully considered the treatment recommendations drafted by the ILCOR Neonatal Life Support Task Force, and incorporated new data published since the systematic reviews were completed. Guideline recommendations were drafted by designated writing group members and then reviewed and refined by all writing group members during regular meetings. The final recommendation wording was reviewed and approved by all writing group members.

Class of Recommendation and Level of Evidence

As with all AHA guidelines, each recommendation in this focused update is assigned a Class of Recommendation (COR) on the basis of the strength of the evidence, alternative treatment options, and the effect on patients and society (Table). The Level of Evidence (LOE) is based on the quality, quantity, relevance, and consistency of the available evidence. For each recommendation, the writing group discussed and approved specific wording of recommendations and the COR and LOE assignments. In determining the COR, the writing group considered the LOE and other factors, including systems issues, economic factors, and ethical factors such as equity, acceptability, and feasibility. These evidence review methods, including specific criteria used to determine COR and LOE, are described more fully in "Part 2: Evidence Evaluation and Guidelines Development" of the 2020 guidelines.[9] The writing group members had final authority over and formally approved these recommendations.

The overall certainty of the evidence base for neonatal resuscitation science is low. Funding and support for high-certainty clinical trials is a significant need in neonatal resuscitation. Of the 8 recommendations in this focused update, no recommendations are supported by Level A evidence (high-quality evidence from >1 randomized controlled trial [RCT], or ≥1 RCTs corroborated by high-quality registry studies). Five recommendations are supported by Level B-R (randomized) evidence (-moderate evidence from ≥1 RCTs) and 1 by Level B-N (nonrandomized) evidence. Two recommendations are based on Level C evidence supported by limited data; no recommendations are based on Level C evidence derived from expert opinion. Likewise, the strength of recommendations is weaker than optimal: no Class 1 (strong) recommendations, 3 Class 2a (moderate) recommendations, 3 Class 2b (weak) recommendations, and 2 Class 3: No Benefit recommendations are included in these guidelines. There are no recommendations designated Class 3: Harm.

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Table. Applying the American College of Cardiology/American Heart AssociationClass of Recommendation and Level of Evidence to Clinical Strategies, Interventions, Treatments, or Diagnostic Testing in Patient Care* (Updated May 2019)

CLASS (STRENGTH) OF RECOMMENDATION	
CLASS 1 (STRONG)	**Benefit >>> Risk**
Suggested phrases for writing recommendations: • Is recommended • Is indicated/useful/effective/beneficial • Should be performed/administered/other • Comparative-Effectiveness Phrases†: – Treatment/strategy A is recommended/indicated in preference to treatment B – Treatment A should be chosen over treatment B	
CLASS 2a (MODERATE)	**Benefit >> Risk**
Suggested phrases for writing recommendations: • Is reasonable • Can be useful/effective/beneficial • Comparative-Effectiveness Phrases†: – Treatment/strategy A is probably recommended/indicated in preference to treatment B – It is reasonable to choose treatment A over treatment B	
CLASS 2b (WEAK)	**Benefit ≥ Risk**
Suggested phrases for writing recommendations: • May/might be reasonable • May/might be considered • Usefulness/effectiveness is unknown/unclear/uncertain or not well-established	
CLASS 3: No Benefit (MODERATE) **(Generally, LOE A or B use only)**	**Benefit = Risk**
Suggested phrases for writing recommendations: • Is not recommended • Is not indicated/useful/effective/beneficial • Should not be performed/administered/other	
Class 3: Harm (STRONG)	**Risk > Benefit**
Suggested phrases for writing recommendations: • Potentially harmful • Causes harm • Associated with excess morbidity/mortality • Should not be performed/administered/other	

LEVEL (QUALITY) OF EVIDENCE‡	
LEVEL A	
• High-quality evidence‡ from more than 1 RCT • Meta-analyses of high-quality RCTs • One or more RCTs corroborated by high-quality registry studies	
LEVEL B-R	**(Randomized)**
• Moderate-quality evidence‡ from 1 or more RCTs • Meta-analyses of moderate-quality RCTs	
LEVEL B-NR	**(Nonrandomized)**
• Moderate-quality evidence‡ from 1 or more well-designed, well-executed nonrandomized studies, observational studies, or registry studies • Meta-analyses of such studies	
LEVEL C-LD	**(Limited Data)**
• Randomized or nonrandomized observational or registry studies with limitations of design or execution • Meta-analyses of such studies • Physiological or mechanistic studies in human subjects	
LEVEL C-EO	**(Expert Opinion)**
• Consensus of expert opinion based on clinical experience	

COR and LOE are determined independently (any COR may be paired with any LOE).

A recommendation with LOE C does not imply that the recommendation is weak. Many important clinical questions addressed in guidelines do not lend themselves to clinical trials. Although RCTs are unavailable, there may be a very clear clinical consensus that a particular test or therapy is useful or effective.

* The outcome or result of the intervention should be specified (an improved clinical outcome or increased diagnostic accuracy or incremental prognostic information).

† For comparative-effectiveness recommendations (COR 1 and 2a; LOE A and B only), studies that support the use of comparator verbs should involve direct comparisons of the treatments or strategies being evaluated.

‡ The method of assessing quality is evolving, including the application of standardized, widely-used, and preferably validated evidence grading tools; and for systematic reviews, the incorporation of an Evidence Review Committee.

COR indicates Class of Recommendation; EO, expert opinion; LD, limited data; LOE, Level of Evidence; NR, nonrandomized; R, randomized; and RCT, randomized controlled trial.

Guideline Structure

These guidelines are organized into knowledge chunks, grouped into discrete modules of information on specific topics or management issues.[9,10] Each modular knowledge chunk includes a table of recommendations that uses the standard AHA nomenclature of COR and LOE. Recommendations are presented in order of COR: most potential benefit (Class 1), followed by lesser certainty of benefit (Class 2), and finally potential for harm or no benefit (Class 3). Following the COR, recommendations are ordered by the certainty of supporting LOE: Level A (high-quality randomized controlled trials) to Level C-EO (expert opinion). A brief introduction puts the recommendations into context with important background information and overarching management or treatment concepts. Recommendation-specific text clarifies the rationale and key study data supporting the recommendations. Hyperlinked references facilitate quick access and review. All writing group members reviewed and approved the final manuscript.

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Document Review and Approval

These guidelines were submitted for blinded peer review to 11 subject-matter experts nominated by the AHA and the AAP. Before appointment, all peer reviewers were required to disclose relationships with industry and any other conflicts of interest, and all disclosures were reviewed by AHA staff. Peer reviewer feedback was provided for guidelines in draft format and again in final format. All guidelines were reviewed and approved for publication by the AHA Science Advisory and Coordinating Committee, the AHA Executive Committee, and the AAP Executive Board. Comprehensive disclosure information for peer reviewers is listed in Appendix 2.

These recommendations augment the last full set of AHA recommendations for neonatal resuscitation made in 2020.[7] All other recommendations and algorithms published in the 2020 guidelines remain the official recommendations of the AHA Emergency Cardiovascular Care Science Subcommittee and writing groups.

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2. UMBILICAL CORD MANAGEMENT

Background

Management of the umbilical cord and placental transfusion at delivery remains an area of robust investigation. The volume of blood transferred from the placenta to the newborn infant and the effect of that transfusion vary on the basis of gestational age at delivery, mode of delivery, the time from delivery to cord clamping, any milking of the umbilical cord, and physiological status of the newborn infant.

Both the American College of Obstetrics and Gynecology and the AAP have produced guidelines about umbilical cord management.[1,2] The most recent guidance from the AHA was published in 2020 and included all gestational ages and methods of placental transfusion.[3] However, the developmental differences between preterm, late preterm, and term infants affect the outcomes of different cord management strategies, including the need for cardiorespiratory support in the delivery room, rate of moderate-to-severe hypoxic-ischemic encephalopathy, hematologic indices, need for admission to the neonatal intensive care unit, and use of therapeutic hypothermia. Because of these variations, ILCOR subsequently performed 2 different systematic reviews for cord management, 1 for late preterm and term infants[4] and 1 for preterm infants.[5] This focused update provides separate recommendations for these 2 distinct groups and relevant evidence published since those meta-analyses through September 2022.

Recommendations for Term/Late Preterm Newborn Umbilical Cord Management		
COR	LOE	Recommendations
2a	B-R	1. For term and late preterm newborn infants ≥34 weeks' gestation who do not require resuscitation, delayed cord clamping (DCC) (≥30 seconds) can be beneficial when compared to early cord clamping (<30 seconds).
2b	B-R	2. For nonvigorous term and late preterm infants (35–42 weeks' gestation), intact cord milking may be reasonable when compared to early cord clamping (<30 seconds).
3: No Benefit	C-LD	3. For term and late preterm newborn infants ≥34 weeks' gestation who do not require -resuscitation, intact cord milking is not known to be beneficial when compared to DCC (≥30 seconds).

Recommendation-Specific Supportive Text

1. Four RCTs (537 infants) found no difference in mortality between early and late cord clamping for term and late preterm infants.[6–9] Low-certainty evidence from 15 studies (2641 infants) shows that DCC results in increased early hematologic indices (either hemoglobin or hematocrit) compared with early cord clamping.[7,8,10–22]
2. One RCT including 1730 nonvigorous newborn infants limited to 35 to 42 weeks' gestation (not including infants 34

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weeks' gestation) comparing intact umbilical cord milking with early cord clamping found no difference in the primary outcome of admission to the neonatal intensive care unit. However, differences in several secondary outcomes (including increased hemoglobin levels and a reduced need for cardiorespiratory support) make umbilical cord milking in this population a reasonable option.[23] Additional studies would be helpful in further evaluating this intervention.

3. There is no evidence available to support intact cord milking compared with DCC in vigorous term and late preterm infants.

Recommendations for Preterm Newborn Umbilical Cord Management		
COR	LOE	Recommendations
2a	B-R	1. For preterm newborn infants <34 weeks' gestation who do not require resuscitation, delaying cord clamping (≥30 seconds) can be beneficial when compared to early cord clamping (<30 seconds).
2b	B-R	2. For preterm newborn infants between 28 and 34 weeks' gestation who do not require resuscitation and in whom DCC cannot be performed, intact cord milking may be reasonable.
3: No Benefit	B-R	3. For preterm newborn infants <28 weeks' gestation, intact cord milking is not recommended.

Recommendation-Specific Supportive Text

1. Sixteen RCTs (2988 infants) showed possible improvement in survival to discharge for infants receiving DCC compared with early cord clamping. DCC varied from 30 seconds to >2 minutes.[24–39] Six studies (351 infants) showed that infants receiving DCC had decreased inotrope use in the first 24 hours.[33,36–38,40,41] Infants receiving DCC had improved hematologic indices within 24 hours and 7 days,[24–27,31–43] and received fewer red blood cell transfusions during admission.[24,27,28,32,35,37–40,42–44]
2. Intact cord milking
   a.
   Versus early cord clamping: In 11 trials (983 infants), infants receiving intact cord milking had higher hematologic indices in the first 24 hours.[43,45–55] In 5 trials (439 infants), infants receiving intact cord milking received fewer inotropes in the first 24 hours.[45–47,49,55] In infants 28 to 32 weeks' gestation, 10 studies (889 infants) could not exclude benefit or harm of intact cord milking for severe intraventricular hemorrhage.[43,45–47,49,51–53,55,56]
   b.
   Versus DCC: A single trial including 292 preterm infants (28–31+6/7 weeks' gestation) showed no increased risk of severe intraventricular hemorrhage for umbilical cord milking compared with DCC.[57]
3. In a single study of 182 infants born 23 to 27+6/7 weeks' gestation not requiring resuscitation, severe intraventricular hemorrhage was significantly higher in those who received umbilical cord milking compared with DCC.[57]

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3. VENTILATORY SUPPORT AFTER BIRTH: DEVICES AND INTERFACES TO ADMINISTER PPV

Background

The 2020 AHA guidelines provided recommendations for when and how to provide PPV, including guidance for -inflation pressures, the use of positive end-expiratory pressure, ventilation rate, and inspiratory time.[1] The recommendations provided in this focused update discuss devices to deliver PPV, and the choice between a face mask and a supraglottic airway as the interface used for PPV.

Several devices are available to administer PPV, including self-inflating bags, flow-inflating bags, and T-piece resuscitators. The choice of PPV device depends on factors reflecting the context at a birthing site: the number of births, the case mix, availability of a compressed gas source, familiarity with the different devices, amount of training required to use each device, and device cost. Because both T-piece resuscitators and flow-inflating bags require a compressed gas source to function, a self-inflating bag should be available as a backup in the event of compressed gas failure when using either of these devices.

Available interfaces for PPV delivery include face masks, nasal prongs, and supraglottic airways. This focused update specifically addresses the choice between face masks and supraglottic airways as the primary interface during PPV.

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Recommendations for Devices Used to Administer PPV for Newborn Infants		
COR	LOE	Recommendations
2a	B-NR	1. It can be beneficial to use a T-piece resuscitator instead of a self-inflating bag, with or without a positive end-expiratory pressure valve, for administering positive-pressure ventilation to newborn infants, particularly for preterm infants.

Recommendation-Specific Supportive Text

1. A meta-analysis of 4 RCTs (1247 term and preterm infants) found that resuscitation with a T-piece resuscitator compared with a self-inflating bag reduced the duration of PPV and decreased risk of bronchopulmonary dysplasia.[2] Although subgroup analyses by gestational age were not feasible in this meta-analysis, bronchopulmonary dysplasia is an outcome that affects preterm infants, and the use of a T-piece resuscitator may present the greatest benefit to preterm infants. The systematic review did not identify any studies that evaluated the use of flow-inflating bags.[2]

Recommendation for Interfaces Used to Administer PPV for Newborn Infants		
COR	LOE	Recommendation
2b	C-LD	1. It may be reasonable to use a supraglottic airway as the primary interface to administer PPV instead of a face mask for newborn infants delivered at ≥34 0/7 weeks' gestation.

Recommendation-Specific Supportive Text

1. A meta-analysis of 6 RCTs (1823 infants delivered at ≥34 0/7 weeks' gestation) found that use of a supraglottic airway decreased the probability of failure to improve with the assigned device, and the rate of endotracheal intubation in the delivery room.[3] Failure to improve with the assigned device was a pragmatic outcome chosen to assess whether primary use of the supraglottic airway or face mask to provide PPV led to improvement of neonates undergoing resuscitation after birth. The duration of PPV and time until heart rate reached >100/min were also shorter with the supraglottic airway.

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Based on available evidence, this recommendation is limited to newborn infants ≥34 0/7 weeks' gestation. All studies included in this meta-analysis were performed in lower-resourced settings. No studies have compared face masks with supraglottic devices for initiating PPV during neonatal resuscitation in high-resourced settings. As a result, the effect size reported in this meta-analysis may not be generalizable to settings with greater availability of health care practitioners with advanced skills and highly trained neonatal resuscitation teams.

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4. KNOWLEDGE GAPS AND PRIORITIES OF RESEARCH ACKNOWLEDGMENTS

This focused update is limited to a review of the science on umbilical cord management in term, late preterm, and preterm newborn infants and on the devices and interfaces used for administering PPV during resuscitation of newborn infants. The topics in the knowledge chunks of this update contain additional questions and practices for which evidence was weak, uncertain, or absent. In addition, the following knowledge gaps require further research:

Umbilical Cord Management

- Optimal management of the umbilical cord in term, late preterm, and preterm infants who require resuscitation at delivery
- Longer-term outcome data, such as anemia during infancy and neurodevelopmental outcomes, for all umbilical cord management strategies

Devices for Administering PPV

- Cost-effectiveness of a T-piece resuscitator compared with a self-inflating bag
- The effect of a self-inflating bag with a positive end-expiratory pressure valve on outcomes in preterm newborn infants
- Comparison of either a T-piece resuscitator or a self-inflating bag with a flow-inflating bag for administering PPV
- Comparison of clinical outcomes by gestational age for any PPV device

Interfaces for Administering PPV

- Comparison of supraglottic airway devices and face masks as the primary interface for PPV in high-resourced settings
- The amount and type of training required for successful supraglottic airway insertion and the potential for skill decay
- The utility of supraglottic airway devices for suctioning secretions from the airway
- The efficacy of a supraglottic airway during advanced neonatal resuscitation requiring chest compressions or the delivery of intratracheal medications

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Disclosures

Appendix 1. Writing Group Disclosures

Writing group member	Employment	Research grant	Other research support	Speakers' bureau/honoraria	Expert witness	Ownership interest	Consultant/ advisory board	Other
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This table represents the relationships of writing group members that may be perceived as actual or reasonably perceived conflicts of interest as reported on the Disclosure Questionnaire, which all members of the writing group are required to complete and submit. A relationship is considered to be "significant" if (a) the person receives $5000 or more during any 12-month period, or 5% or more of the person's gross income; or (b) the person owns 5% or more of the voting stock or share of the entity, or owns $5000 or more of the fair market value of the entity. A relationship is considered to be "modest" if it is less than "significant" under the preceding definition.

*Modest.

†Significant.

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Appendix 2. Reviewer Disclosures

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