The Textbook of Neonatal Cardiopulmonary Resuscitation

NCPR

# Based on the 2020 Guidelines of the Japan Resuscitation Council

Fourth Edition

Editor: Shigeharu Hosono
Chair, Committee on Neonatal Resuscitation
Japan Society of Perinatal and Neonatal Medicine

MEDICAL VIEW

The instructions,adverse reactions,and administration schedules described in this text may change.When handling drugs mentioned in this text,carefully review the information provided by the manufacturer.

The Japan Society of Perinatal and Neonatal Medicine periodically updates its information on neonatal cardiopulmonary resuscitation.

Visit the websites below for the latest information:

Japan Society of Perinatal and Neonatal Medicine:
https://www.jspnm.com/

The Japan Society of Perinatal and Neonatal Medicine
Neonatal Cardiopulmonary Resuscitation(NCPR) Project:
https://www.ncpr.jp/

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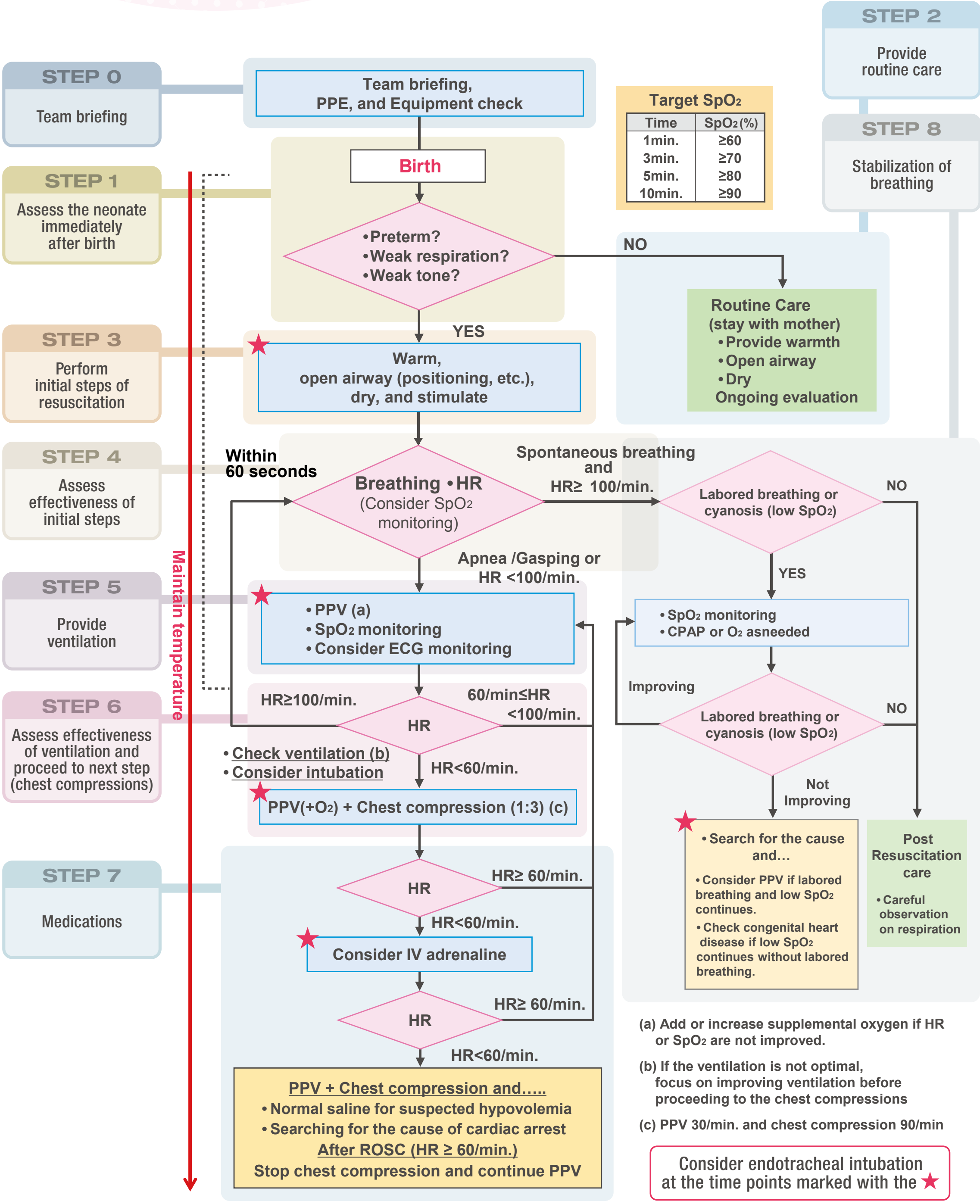
# NCPR2020 Algorithm



Chapter

1

# What is Neonatal Cardiopulmonary Resuscitation?

Chap.1

# The Neonatal Cardiopulmonary Resuscitation (NCPR) project

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## I Characteristics of neonatal asphyxia and neonatal cardiopulmonary resuscitation (CPR)

### 1 Percentage of neonates in need of resuscitation at birth

With advances in obstetrics management, especially the widespread use of fetal heart rate monitoring, it has become possible to assess the well-being of fetuses, and systems have been put in place for general and regional perinatal medical centers to manage and carry out high-risk deliveries. A growing number of facilities, including general and some regional perinatal medical centers, can perform emergency cesarean sections at any time of day within 30 min after making the decision to perform surgery. The immediate transportation of pregnant women to general or regional perinatal medical centers after the confirmation of non-reassuring fetal status (NRFS) at a local obstetrics clinic and the allocation of appropriate staff for advanced neonatal resuscitation at facilities where cesarean sections are performed has substantially contributed to improving the prognosis of neonates. Nevertheless, even when fetal heart rate monitoring findings are normal immediately before delivery following an uneventful course of pregnancy and delivery, neonatal asphyxia is a common complication.

After delivery, as soon as the fluids that fill the airway, including the alveoli, are replaced by air upon the cessation of placental circulation by clamping and cutting of the umbilical cord, the fetus must make a drastic transition to neonatal respiration and hemodynamics to adapt to extrauterine life. Approximately 85% of term neonates start breathing within 10-30 s after birth[1]. Approximately 10% of neonates start breathing in response to drying and stimulation[2]. Approximately 5% start breathing spontaneously after receiving positive pressure ventilation (PPV), including intubation. Approximately 2%, 0.1%, and 0.05% require respiratory support with endotracheal intubation, chest compressions, and adrenaline administration plus ventilation and chest compressions, respectively[3-6]. When spontaneous breathing does not occur in neonates, appropriate and timely interventions are required to hinder the progression of hypoxia and ischemia, thereby preventing the onset of hypoxic-ischemic encephalopathy. Given that the number of births was 865,239 in 2019[7], the figures cited above mean that slightly fewer than 130,000 neonates (approximately 1 every 4 min) required some kind of support to stabilize respiration and circulation at birth. Preterm infants accounted for 5.6% of all births in 2014[8], and many of them were likely delivered with a pediatrician in attendance at a general or regional perinatal medical center.

## 2 Asphyxiated neonates can be resuscitation with relatively simple procedures

Term neonates who require some sort of procedure account for approximately 15% of all deliveries. Two-thirds of these neonates (approximately 10% of all deliveries) start beathing spontaneously after being dried and stimulated, and the remaining one-third (approximately 5% of all deliveries) start breathing spontaneously after receiving PPV, including endotracheal intubation. Only approximately 0.1% of term neonates require chest compressions or further treatment. In other words, even though some neonates do not spontaneously breathe at birth, approximately 90% of them start breathing spontaneously after intervention with drying and stimulation and bag-mask ventilation. When endotracheal intubation and chest compressions are included in the interventions, approximately 99% of neonates can be resuscitated; medication (i.e., adrenaline) and normal saline must be ready for use, but an automated external defibrillator (AED), which is commonly used for older children and adults, is not necessary for neonatal resuscitation.

## 3 Asphyxia at medical facilities during deliverysimple procedures

In Japan, 99.9% of deliveries take place at medical facilities [9]. Therefore, it is possible to achieve efficient training effects by providing appropriate resuscitation supplies and regularly training limited medical staff in limited procedures such as bag and mask ventilation and chest compressions.

# II Distinguishing features of the Japanese system for delivery

In North America, most deliveries take place at a general hospital with a pediatrician in attendance. In Japan, with the improvement of the perinatal medical care system in recent years, a system is becoming established in which pregnant women are transported to a general or regional perinatal medical center to deliver their babies with a pediatrician in attendance when a high-risk delivery or high-risk neonate is anticipated. However, it is impossible to predict all deliveries of high-risk neonates, and it is not uncommon for neonates to suddenly develop problems with adaptation to extrauterine life, even when the course of pregnancy and delivery was completely uneventful.

Furthermore, in Japan in 2018, only 55.1% of deliveries took place at hospitals, and 44.3% and 0.5% took place at obstetric clinics and midwifery centers, respectively [9]. The remaining 0.1% took place at home and at other locations. This means that, if high-risk deliveries and/or fetal abnormalities are not predicted, most deliveries take place without a pediatrician in attendance. On the other hand, there are a certain number of miscarried deliveries, such as home deliveries and deliveries in cars, in which obstetricians and midwives are not involved, and emergency teams, including paramedics, respond to deliveries and newborn.

# III The importance of training perinatal care providers in standard neonatal resuscitation

For the reasons described above, it is important that not only pediatricians but all obstetricians, midwives, and nurses who are involved in delivery have mastered the theory, techniques, and attitudes of standard neonatal resuscitation in order to appropriately treat neonates who cannot smoothly make the transition to the extrauterine environment, thereby avoiding unnecessary problems for their parents. Also, many medical professionals have had the alarming experience where a neonate who appeared healthy soon after birth fell into respiratory arrest or bradycardia during early skin-to-skin contact or after having a bath, being fed, or crying. To respond appropriately to such situation, it is desirable that doctors and nurses who work in the pediatric ward including the neonatal unit, neonatal intensive care unit (NICU), and pediatric intensive care unit (PICU) have mastered standard neonatal resuscitation.

Against this background, the guidelines introduced here are intended to be used at obstetric clinics and midwifery centers, rather than unmodified guidelines based on the assumption that deliveries are carried out with a pediatrician in attendance at a general hospital as in the United States. Meanwhile, the person in charge in the clinical setting must strive to establish a system and provide training opportunities for relevant staff, so that safer and more effective resuscitation can be provided in accordance with international standards.

## IV The ultimate goal of the NCPR project

The American Heart Association (AHA) International Guidelines 2000 for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care (AHA2000)[10] recommend that "at least one person skilled in initiating neonatal resuscitation should be present at every delivery. An additional skilled person capable of performing a complete resuscitation, including the administration of medications and endotracheal intubation, should be immediately available to provide help. More than one dedicated staff member must attend an anticipated high-risk delivery solely for care of the neonate". This was again emphasized in the Consensus on Science with Treatment Recommendations (CoSTR) 2005[11] published by the International Liaison Committee on Resuscitation (ILCOR) in 2005.

Thus, the ultimate goal of the NCPR project is to establish a system in which all personnel involved in perinatal medical care master standard neonatal resuscitation by attending practical training sessions, and dedicated staff skilled in the initiation of neonatal resuscitation are available at every delivery.

The NCPR project estimates that the number of personnel involved in perinatal medical care is 75,000. From the beginning of the training project in 2007 to the end of December 2015, the total number of participants was 174,167 (97,856 for the A course, 48,650 for the B course), and 67,643 were registered as holding a certificate of completion.[12]

## V The significance of neonatal cardiopulmonary resuscitation training by simulation in small-group

Knowledge acquisition alone is not sufficient to allow medical professionals to perform resuscitation procedures calmly and adequately when they encounter a neonate with unanticipated asphyxia. Practical training for individual skills in neonatal cardiopulmonary resuscitation (NCPR) using manikins and real equipment is necessary, as is gaining an understanding of theory and techniques through audiovisual aids such as slides and videos.

Furthermore, small-group courses, in which participants' abilities to make decisions and implement practical procedures are formatively evaluated through simulation exercises using scenarios based on asphyxia situations that frequently occur in the real world, were shown to increase the effectiveness of training[13-17].

## VI Criteria for teaching standards in neonatal resuscitation courses

(1) Compliance with evidence-based international standards and feasible in actual practice in Japan.
(2) Universally applicable to all professionals who are likely to be involved in NCPR.
(3) Able to be completed by individuals who are already working as health care professionals, as well as recent graduates.
(4) Acceptable time and financial costs to allow the courses to be completed by all medical professionals who may attend a delivery.
(5) Able to be widely implemented to avoid disparities among regions and institutions.
(6) Compatible with other professional training programs and certification systems.

## VII Anticipated effects of training all perinatal care providers in standard neonatal cardiopulmonary resuscitation

(1) The standardization of NCPR will be promoted.
(2) Skills of individuals, including pediatricians, obstetricians, gynecologists, obstetric anesthetists, midwives, nurses, and ambulance crews, will be improved.
(3) Promotion of team medicine: The shared use of a standard algorithm will facilitate cooperation among staff and enable team members who do not initiate resuscitation to provide appropriate assistance and preparation. This is important for improving the success rate of resuscitation, a situation in which a slight delay makes a critical difference.
(4) The responsibilities of medical professionals will become clearer in cases in which both the mother and the neonate require emergency treatment.
(5) Midwives and nurses will improve their neonatal resuscitation skills, allowing them to complement the shortage of pediatricians, obstetricians, and gynecologists, which is considered the primary factor in a perinatal care crisis.
(6) The quality of emergency medical care in neonatal units, pediatric wards, and emergency and outpatient departments will be improved.
(7) Such training will contribute to the quality assurance of certification and specialist programs related to perinatal medicine.
(8) A system will be implemented in which every delivery is attended by a designated person capable of initiating neonatal resuscitation.

## VIII Practical skills courses and a registration system for training perinatal care providers across Japan in standard neonatal cardiopulmonary resuscitation [12)]

Against this background, in 2017, the Japan Society of Perinatal and Neonatal Medicine initiated a nationwide project in which courses are provided to those who are involved in perinatal care so that they can learn the NCPR guidelines that are in compliance with international standards. In terms of practical courses for those involved in neonatal medical care across Japan, the society has accredited a course on prehospital neonatal resuscitation since April 2020, in addition to two existing courses for new participants in neonatal resuscitation within hospitals. Additionally, courses for recipients of completion certificates were initiated in April 2015.

**(1) Advanced Neonatal Resuscitation Course (Course A)**

Main targets: Obstetricians, gynecologists, pediatricians, anesthetists, emergency medicine doctors, doctors in other perinatal medical facilities, nurse specialists and midwives, paramedics, and others.

Contents: Advanced neonatal resuscitation techniques, including medications and endotracheal intubation.

**(2) Basic Neonatal Resuscitation Course (Course B)**

Main targets: General practitioners, nurses and midwives, early-stage interns, paramedics, medical students, students in the nursing or midwifery department, and others.

Contents: Basic neonatal resuscitation techniques, with an emphasis on bag-mask ventilation and chest compressions.

The main targets of and participants in Course B are advised to participate in Course A for further improvement of their knowledge and skills.

**(3) Prehospital Neonatal Resuscitation (Course P)**

Main targets: Paramedics, ambulance crew members, firefighters, and others.

Contents: Neonatal resuscitation in cases of delivery outside a medical facility.

**(4) Skill training course (Course S)**

Main targets: Recipients of certificates of completion of Course A and Course B.

Contents: A review course comprising lectures, skill practice, and scenario-based practice for maintaining the quality of resuscitation techniques.

Recipients of a Course A certificate can become qualified instructors of Course B (J instructors) after learning necessary teaching methods ranging from how to prepare the course to how to conduct the final assessment. These methods are learned through participation in at least one society-accredited course as an assistant instructor and obtaining the recommendation of a practicing instructor.

To become a qualified instructor of Course A, recipients of a Course A certificate must participate in at least two society-accredited courses (at least one course must be Course A) as an assistant instructor, receive a recommendation from a practicing instructor to participate in the training courses for becoming a Course A instructor (Course I), and complete Course I to obtain a Course I certificate.

It is preferable that the certificates be issued by a nonprofit academic association; therefore, the Japan Society of Perinatal and Neonatal Medicine, whose members are professionals involved in neonatal medicine in pediatrics and obstetrics departments, is taking the initiative, along with other societies such as the Japan Association of Obstetricians and Gynecologists, the Japan Academy of Midwifery, the Japanese Midwives' Association, the Japanese Nursing Association, the Japan Academy of Neonatal Nursing, the Japan Society of Obstetrics and Gynecology, the Japan Pediatric Society, the Japan Society of Maternal Health, and the Japan Resuscitation Council.

## IX Role in the Ministry of Health, Labour, and Welfare's "Project to Establish Perinatal Care Measures and Systems"

General and regional perinatal medical centers that receive public funding have a public responsibility to implement projects to train those involved in perinatal medical care in each region.

- In the first phase of this training, the Neonatal Resuscitation Committee of the Japan Society of Perinatal and Neonatal Medicine plays a pivotal role in providing training courses for those who plan to become Course A instructors for the main targets, namely, doctors at general and regional perinatal medical centers, provisional senior fellows of the Japan Society of Perinatal and Neonatal Medicine, and those responsible for education and training in the Japan Association of Obstetricians and Gynecologists, the Japan Academy of Midwifery, the Japanese Midwives' Association, and the Japan Academy of Neonatal Nursing.
- In the second phase, qualified Course A instructors organize Course A primarily for doctors at general and regional perinatal medical centers and those who are responsible for education and training at relevant associations and societies.
- In the third phase, doctors at general and regional perinatal medical centers and those who are responsible for education and training at relevant associations and societies organize Course A and Course B for doctors, midwives, and nurses at local obstetrics clinics. In this way, ideally, everyone involved in perinatal medical care will complete Course A or Course B.

As of December 2020, a total of 4,705 instructors (3,007 Course A instructors and 1,698 Course B instructors) are working actively across Japan [12], and more than 170,000 health care professionals have participated in NCPR-accredited courses; Phase 3 is well underway.

It is desirable that in the future, all board-certified pediatricians, obstetricians, and gynecologists become qualified Course A instructors and that Course A is integrated into training in pediatrics departments and obstetrics and gynecology departments during the early post-graduate clinical rotation. The Japan Institute of Midwifery Evaluation started the certification program for the Clinical Ladder® of Competencies for Midwifery Practice (CLoCMiP®) in 2015, which requires the completion of Course B or a more advanced course within a specified period [18].

## X Indications for neonatal resuscitation based on the NCPR guidelines [19]

A neonate is medically defined as a child younger than 28 days old. Differences between pediatric cardiopulmonary resuscitation (CPR) and neonatal CPR have become more apparent since the introduction of CoSTR2010. Because of this, confusion is expected when CPR is performed on an infant younger than 1 month of age in a pediatric ward or a pediatric emergency department. The Japan Resuscitation Council has issued the following recommendations for infant CPR based on the idea that the highest priority is to avoid delays in the initiation of resuscitation due to excessive concern about whether a patient should be classified as a neonate or an infant.

- Neonatal resuscitation procedures should be performed on neonates who are in the delivery room or neonate room and on infants (corrected age <1 year) who are staying in the NICU.
- Pediatric CPR can be performed on infants in cardiac arrest who are younger than 28 days old (neonates) during prehospital care or emergency resuscitation at a pediatric ward, a pediatric intensive care department, or an outpatient department.
- The selection of resuscitation procedures for neonates, NCPR or pediatric CPR should be based on predetermined institutional policies.

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# Assessment of certainty of evidence and strength of recommendation using the GRADE approach

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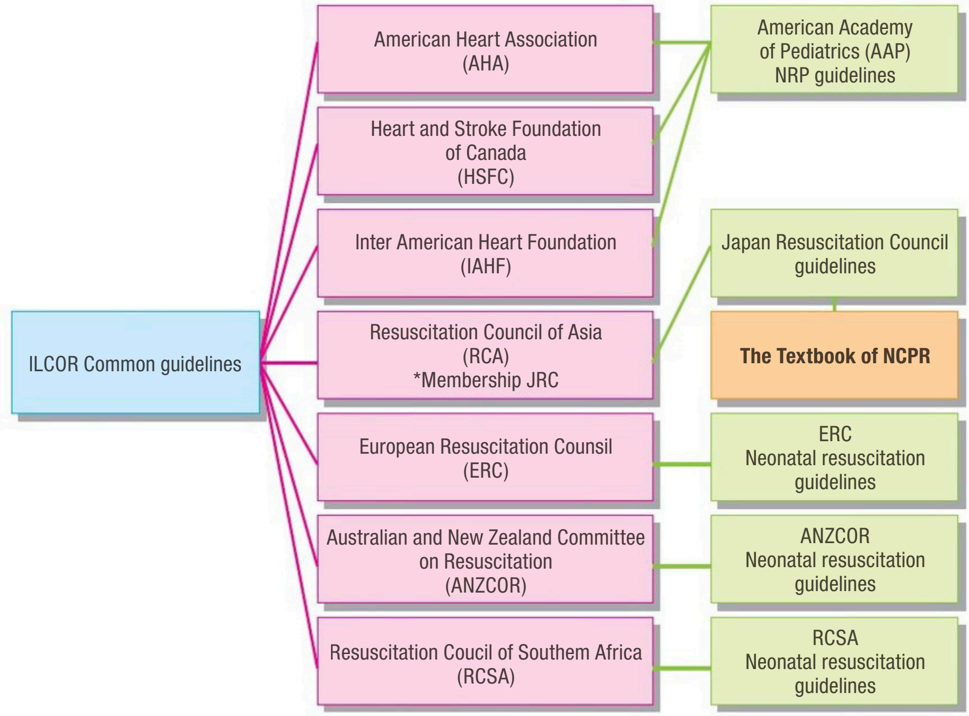
## I Assessment of certainty of evidence using the GRADE approach

Neonatal cardiopulmonary resuscitation (NCPR) is based on the neonatal resuscitation guidelines of the Japan Resuscitation Council (JRC), which were developed in accordance with the neonatal resuscitation guidelines established by the International Liaison Committee of Resuscitation (ILCOR). The ILCOR is an international organization consisting of resuscitation councils from various regions of the world, and representatives from Japan have participated in updating and revising the neonatal resuscitation guidelines every 5 years. As shown in **Fig. 1**, the ILCOR's international guidelines are used by resuscitation councils around the world, with minor modifications appropriate to each region. The JRC's neonatal resuscitation guidelines, on which this NCPR textbook is based, were developed exclusively for Japan based on the 2020 ILCOR guidelines, taking into account the health care system, clinical practices, and sociocultural background in Japan.

The ILCOR conducts systematic reviews of various issues in neonatal resuscitation (using the Patient-Intervention-Control-Outcome [PICO] model), develops the Consensus on Science with Treatment Recommendations (CoSTRs), and develops neonatal resuscitation guidelines based on the CoSTRs. Since 2010, the ILCOR's resuscitation guidelines have been developed based on the Grading of Recommendations, Assessment, Development and Evaluation (GRADE) approach, which has become a global standard for conducting systematic reviews and developing clinical practice guidelines (**Fig. 2**).[1, 2] The GRADE approach was developed by the GRADE Working Group, an international group of experts in systematic reviews and clinical practice guidelines, in collaboration with the Cochrane Collaboration, and it is still evolving. It is a global standard approach that has been adopted by many leading organizations around the world, including the WHO, the Cochrane Collaboration, ILCOR, UpToDate, and the Medical Information Distribution Service (MINDS) of the Japan Council for Quality Health Care.

The GRADE approach has the following characteristics: 1) it assesses the risk of bias and certainty of evidence (previously called the "quality of evidence") of each study on an outcomes basis; 2) it develops recommendations that are not only based on scientific results but also incorporate various perspectives, such as patients' values and preferences, costs, and health care resource utilization; and 3) it clearly separates the certainty of evidence from the strength of recommendation in its assessment.

**Fig. 1** Country-specific neonatal resuscitation guidelines based on ILCOR guidelines



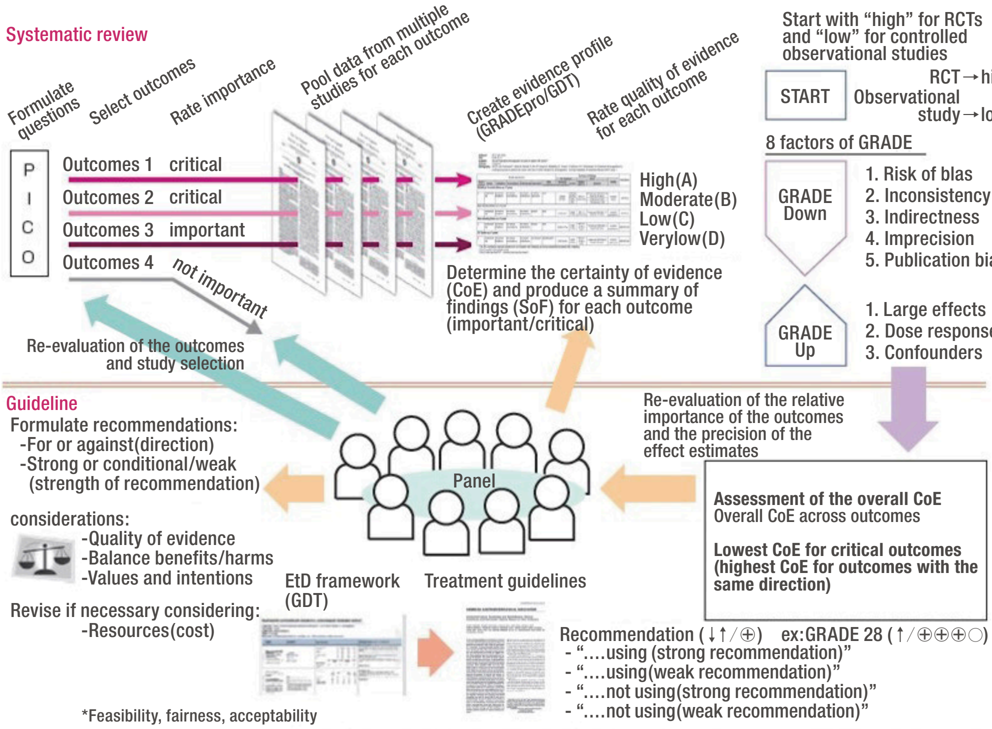

AHA : American Heart Association, HSFC : Heart and Stroke Foundation of Canada, IAHF : Inter American Heart Foundation, RCA : Resuscitation Council of Asia, ERC : European Resuscitation Council, ANZCOR : Australian and New Zealand Committee on Resuscitation, RCSA : Resuscitation Council of Southern Africa, AAP : American Academy of Pediatrics, JRC : Japan Resuscitation Council

## II Assessment of strength of recommendation

In the GRADE approach, the first step is to assess the risk of bias of individual studies for each outcome. Then, the overall results of the relevant studies are summarized for each outcome and assessed according to the following five parameters: risk of bias, inconsistency, indirectness, imprecision, and other considerations, including publication bias. Based on the results of these assessments, the certainty of evidence is rated on a four-point scale: "high," "moderate," "low," or "very low. The details of the certainty of evidence assessment for each outcome are usually summarized and published in an evidence table (e.g., an evidence profile table or summary of findings table). This table is the core of the scientific rationale for the ILCOR guidelines but is not the only basis on which recommendations are made.

The direction and strength of recommendations are determined based on four criteria: (1) the overall certainty of evidence across outcomes, (2) the benefit-harm balance, (3) values and intentions, and (4) resource requirements and costs (optional). Other factors that are taken into consideration include feasibility, fairness, and acceptability. The final strength of recommendation is divided into two levels: strong recommendations (expressed as "it is recommended that…") and weak recommendations (expressed as "it is suggested that…"). This process of determining recommendations is usually published in an evidence-to-decision (EtD) table. This attempt to make the decision-making process as public and transparent as possible is another important merit of the GRADE approach.

**Fig. 2** Process of creating recommendations using the GRADE system




（相原守夫：診療ガイドラインのためのGRADEシステム 第3版. p19. 東京. 中外医学社. 2018より転載）

## III Differences among the three types of reviews

In addition to the traditional systematic review (SysRev), two new review methods were introduced in the 2020 revision of CoSTR: the scoping review (ScopRev) and the evidence update (EvUp). To understand the process used in the latest revision of the CoSTR, it is important to understand the differences among these three types of reviews, as shown in **Table. 1**.

**Table. 1** Three types of reviews in CoSTR2020

| types of reviews | Details and purpose | effect on CoSTR |
|---|---|---|
| Systematic Review (SysRev) | To evaluate the effectiveness of an intervention by conducting a regular SysRev based on clarified clinical questions (according to the Patient-Intervention-Control-Outcome [PICO] model). | Reflected in the ILCOR's CoSTRs |
| Scoping Review (ScopRev) | Usually used to review clinical questions that are broader or less clear than those addressed in a SysRev and often used to clarify PICO or assess PICO priorities. The purpose is to connect to a subsequent SysRev. | Usually not reflected in the ILCOR's CoSTRs. A formal SysRev must be performed to change the recommendations. |
| Evidence Update (EvUp) | This type of review is used to search for newly-published literature on PICOs for which the ILCOR has already conducted a SysRev, with the aim of determining whether to repeat the SysRev. | |

References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# Major revisions to the 2020 Japan Resuscitation Council Guidelines on Neonatal Resuscitation based on Consensus 2020

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The most important skill in neonatal resuscitation is the ability to introduce effective ventilation without delay. The concept underlying the previous revision of the Neonatal Cardiopulmonary Resuscitation Guidelines 2015 (NCPR2015) was that the actions to be taken within 60 s in the algorithm are the process for introducing ventilation without delay, and the initial steps taken in the algorithm are to prepare for effective ventilation in one aspect.[1)] Although the importance of ventilation remains unchanged in NCPR2020, the following changes have been made to reflect revisions made in CoSTR2020.[2)]

The most important aspect of neonatal resuscitation is the lifesaving sequence leading to ventilation or chest compressions. The importance of briefing is clearly stated because team performance is as important as individual skills for introducing effective ventilation without delay. If the patient's condition does not improve with effective ventilation or chest compressions, adrenaline should be administered in the presence of a pediatrician as early as possible. During the stabilization sequence, when labored breathing or cyanosis is present, CPAP or free-flow oxygenation should not be administered immediately; instead, $SpO_2$ monitoring should be performed, and treatment should be selected according to the patient's condition and followed by evaluation.

The following sections provide a summary of the changes from NCPR2015 to NCPR2020[3)] (**Table. 1**) and an overview of the 22 issues addressed in the latest revision; additionally, they summarize the actual flow of NCPR.

## I Revisions and rationale

### 1 Emphasizing the lifesaving sequence as the essence of neonatal resuscitation

Until 2015, the algorithm started with initial steps and the subsequent assessment of respiration and heart rate and then separated into the left branch (lifesaving sequence) and the right branch (the stabilization sequence), which were presented in a contrasting manner. However, because the main path of neonatal resuscitation is the lifesaving sequence, starting with the introduction of effective ventilation without delay when there is no spontaneous breathing or when the heart rate is less than 100 bpm, the assessment and intervention steps of the lifesaving sequence have been arranged in a linear fashion starting from birth, and the stabilization sequence has been arranged as a branch to the right.

**Table. 1** Major changes in NCPR2020

| | Item | Changes in the Japanese Neonatal Cardiopulmonary Resuscitation Guidelines 2020 | Reason for the change and operational considerations | PICO CQ | Types of reviews |
|---|---|---|---|---|---|
| 1 | Briefing | The "Briefing" and "Birth" boxes have been added before the step of "Assess the neonate immediately after birth" in the algorithm. | A systematic review concluded that briefing or debriefing may improve short-term clinical outcomes for neonates and performance outcomes for staff. To improve team performance, understand the expected resuscitation requirements of the neonate, confirm the availability of equipment and role sharing, and ensure that measures are in place to protect health care professionals against infection. | NLS1562 | ScopRev |
| 2 | Oxygenation after the initiation of chest compressions | The term "oxygenation" has been added to the chest compressions step, following ventilation. | Since oxygenation during chest compressions is often omitted during scenario-based practical training at workshops, the term has been added to the algorithm to improve awareness of the need for oxygenation. | | |
| 3 | Adrenaline and volume infusion | The adrenaline administration step has been separated from the medication step as an intervention to be performed before the administration of circulatory volume expanders. | There is no evidence to recommend routine supplementation with circulatory volume expanders in nonbleeding neonates. Therefore, during the medication step, the administration of circulatory volume expanders should not precede the administration of adrenaline.<br>For adrenaline administration, umbilical venous infusion is recommended as the administration route of first choice. Even if the first dose of adrenaline was given intratracheally, the subsequent establishment of the venous route should not be delayed. If the heart rate is still below 60 bpm after intratracheal adrenaline administration and if the venous route is available, intravenous adrenaline should be administered regardless of the interval from the preceding intratracheal administration. | NLS593<br>NLS616 | SysRev<br>SysRev |
| 4 | Evaluation of polypnea and cyanosis and subsequent intervention | The requirement for proceeding to the stabilization sequence has been changed from "both labored breathing and cyanosis" to "either labored breathing or cyanosis." | CoSTR2020 recommends proceeding to intervention if there is either labored breathing or cyanosis. In NCPR2020, the requirement for proceeding to the step of "attach an $SpO_2$ monitor and consider administering CPAP or oxygen as needed" has been changed from "both" labored breathing and cyanosis to "either" of them. | | |
| 5 | Assessment and intervention after the application of CPAP or free-flow oxygenation | A new evaluation criterion, "improving", has been added after the administration of CPAP or free-flow oxygen, along with the recommendation to continue the same intervention. | In clinical practice, it is practical to continue CPAP or oxygenation when the patient's condition is improving. Therefore, the evaluation criterion "improving" has therefore been added, and if this criterion is met, the same intervention should be continued, and the presence/absence of labored breathing and cyanosis (poor oxygenation) should be reassessed later. | | |
| 6 | Postresuscitation care | Changed to recommend only "continue careful respiratory monitoring." | Postresuscitation care should be initiated only when the symptoms have resolved or improved. | | |

SysRev: Systematic Review, ScopRev: Scoping Review

## 2 Inclusion of "briefing" as a prenatal step

A systematic review of the effects of briefing (preliminary conference) and postresuscitation debriefing (review) concluded that briefing or debriefing may improve short-term clinical outcomes for neonates and performance outcomes for staff. The use of briefing and debriefing was also recommended for simulation education and learning in clinical settings. Briefing has been added along with "birth" in the algorithm because of its importance not only for the conventional prevention of infection through blood and other bodily fluids and the confirmation of the availability of resuscitation supplies but also for protection against droplet infection during the severe acute respiratory syndrome-corona virus 2 (SARS-CoV-2) pandemic and the preparation of protective equipment.

## 3 Addition of “oxygenation” to the chest compressions step following ventilation

If the heart rate is less than 60 bpm on assessment after 30 s of effective ventilation, chest compressions with oxygenation should be initiated while continuing ventilation. Given that the provision of oxygenation during chest compressions is often omitted during scenario-based practical training at workshops, it has been included in the latest revision of the algorithm.

The oxygen concentration at the start of ventilation remains the same: room air for neonates ≥ 35 weeks of gestation and a low oxygen concentration of 21% to 30% for preterm neonates < 35 weeks of gestation.

## 4 Listing “adrenaline administration” as a separate step because it is the first-line medication

An evidence update on volume expanders was conducted. The results showed that there was no evidence to recommend routine use of circulatory volume expanders in nonbleeding neonates. Therefore, the administration of circulatory volume expanders should not precede the administration of adrenaline, and if the heart rate remains below 60 bpm even after effective ventilation and chest compressions with oxygen, adrenaline should be the first-line medication. Thus, “adrenaline” has been listed as a separate step in the latest revision.

A systematic review of adrenaline administration was conducted, and it recommended umbilical venous infusion as the first-choice administration route for adrenaline. The dose and dosing interval (every 3 to 5 min if the heart rate remains below 60 bpm with intravenous or intratracheal administration) remain unchanged. Even if the first dose was given intratracheally, the establishment of the venous route should not be delayed, and if the heart rate is still below 60 bpm after intratracheal adrenaline administration and if the venous route is available, intravenous adrenaline administration should be performed as soon as possible regardless of the interval from the preceding intratracheal administration. In such cases, additional doses should be administered at the usual intravenous dose.

## 5 Changing the requirement for proceeding to the stabilization sequence from “both labored breathing and cyanosis” to “either labored breathing or cyanosis”

In the NCPR2015 algorithm, the patient was examined for labored breathing and cyanosis, and if both were present, CPAP or oxygen was administered with $SpO_2$ monitoring. If either of them was present, the algorithm proceeded to postresuscitation care, during which the cause was explored and the introduction of CPAP was considered if there was labored breathing alone, and the possibility of a cyanotic heart disease was considered if there was cyanosis alone. In clinical practice, if cyanosis or labored breathing is present, it is practical to perform $SpO_2$ monitoring for differential diagnosis and to provide treatment as necessary. In addition, in accordance with CoSTR2020, in which the presence of labored breathing or cyanosis leads to the introduction of intervention, NCPR2020 also recommends to "attach an $SpO_2$ monitor and administer CPAP or oxygen as needed" if labored breathing or cyanosis is present.

## 6 In the stabilization sequence, the first intervention is not performed immediately; instead, the first step has been changed to "attach an $SpO_2$ monitor and administer CPAP or oxygen as needed"

To proceed to the stabilization sequence, the patient must have spontaneous breathing and a heart rate of 100 bpm or more. In this state, the brain and organs, including the heart, do not immediately suffer hypoxic-ischemic damage. Therefore, the first step has been changed to "attach an $SpO_2$ monitor and consider administering CPAP or oxygen as needed." Even in neonates who are breathing spontaneously or crying well after initial resuscitation, generalized cyanosis may persist, or oxygenation may be poor for the first few minutes after birth. Therefore, it is not necessary to immediately administer oxygen to a neonate who has cyanosis alone, without labored breathing.

## 7 The term "poor oxygenation" has been added after cyanosis

Systemic cyanosis is a condition that occurs when the hemoglobin (Hb) content in capillary blood is reduced by more than 5 g/dL. Oxygen saturation represents the proportion of oxygen-bound Hb relative to the total amount of Hb in all red blood cells in the arterial blood. It is not possible to determine a universal threshold for arterial oxygen saturation at which cyanosis occurs as it varies depending on the Hb concentration. Thus, generalized cyanosis and poor oxygenation are not synonymous. Poor oxygenation is defined as a level of oxygenation below the reference value described in the NCPR algorithm. Therefore, the presence of poor oxygenation may be determined by skin color, namely the presence or absence of cyanosis, before the $SpO_2$ monitor is applied or in situations where $SpO_2$ information is not available. In facilities where an $SpO_2$ monitor is available, however, poor oxygenation should be determined by arterial blood oxygen saturation.

## 8 A new evaluation criterion, "improving", has been added after the administration of CPAP or free-flow oxygen

The NCPR2015 algorithm stated that if both labored breathing and cyanosis are present, CPAP or oxygenation should be started immediately after an $SpO_2$ monitor is applied, and if both labored breathing and cyanosis is still present after 30 s, the patient should proceed to the ventilation step. In clinical practice, it is practical to continue CPAP or oxygenation when the patient's condition is improving. Therefore, the evaluation criterion "improving" has been added, and if this criterion is met, the same intervention should be continued, and the presence or absence of labored breathing and cyanosis (poor oxygenation) should be re-assessed later.

## 9 Action to be taken when there is no improvement in labored breathing or cyanosis (poor oxygenation) during postintervention assessment has been changed to "consider the response" while searching for the cause

In to the NCPR2015 algorithm, the absence of improvement in labored breathing and cyanosis led to the introduction of ventilation. In contrast, the NCPR2020 algorithm recommends that when there is no improvement in labored breathing or cyanosis (poor oxygenation) after the administration of CPAP or free-flow oxygenation, instead of introducing ventilation in all cases, either of the following actions should be taken while searching for the cause: "consider ventilation if labored breathing and poor oxygenation persist" and "consider the possibility of cyanotic heart disease if only poor oxygenation persists." If there is no cyanosis (poor oxygenation) and only labored breathing persists, then there is no problem with oxygenation, and the resuscitation procedure is completed. The next step is to identify the causative disease and initiate the appropriate treatment. This is because in NCPR, labored breathing encompasses the four symptoms of nasal flaring, grunting retractions, and tachypnea, and because these symptoms are characteristic of different conditions, it is necessary to determine the underlying cause and select the appropriate treatment.

## 10 Postresuscitation care has been changed to recommend only "continue careful respiratory monitoring"

In the NCPR2015 algorithm, the presence of labored breathing or cyanosis led to the initiation of postresuscitation care, in which careful respiratory monitoring should be continued while exploring the cause, the introduction of CPAP should be considered if only labored breathing persists, and the possibility of cyanotic heart disease should be considered if only cyanosis persists. In the NCPR2020 algorithm, postresuscitation care is initiated only when there is neither labored breathing nor cyanosis (poor oxygenation), and thus, only "continue careful respiratory monitoring" is recommended.

## 11 Simplification of notes (a) and (b)

The following changes have been made for simplification:

(a) Ventilation: In more than 90% of cases of neonatal asphyxia, bag-mask ventilation alone improves the situation, and there is no need to intubate quickly. Start with room air and add oxygen if there is no improvement in skin color or $SpO_2$.

→ Add or increase oxygen if there is no improvement in heart rate or $SpO_2$.

(b) If the patient is not properly ventilated, do not proceed to chest compressions; instead, concentrate on securing and implementing ventilation.

→ If the patient is not properly ventilated, do not proceed immediately to chest compressions; instead, try to ensure effective ventilation first.

No change has been made to note (c).

# II Summary of 22 issues addressed in the CoSTR2020 and recommendations

The 22 issues addressed in the CoSTR2020[2] are listed in **Table. 2**. Seven systematic reviews (SysRev), 3 scoping reviews (ScopRev), and 12 evidence updates (EvUp) are discussed. The following sections provide a summary of these issues.

## 1 Anticipation and preparation

### (1) Prediction of the need for respiratory support in the delivery room (NLS 611: EvUp)

CoSTR2020: Cesarean deliveries performed under local anesthesia without preidentified risk should be attended by a health care professional with experience in ventilation, but it is not necessary for the delivery to be attended by a physician skilled in intubating neonates. This recommendation is unchanged from CoSTR2010.

In NCPR2015, it was stated that "Research has shown that the need for endotracheal intubation during resuscitation is no higher in term infants born by cesarean section under local anesthesia than in term infants delivered vaginally. Therefore, attendance by personnel capable of ventilation should be sufficient for cesarean deliveries of risk-free term infants under local anesthesia." This recommendation remains unchanged in NCPR2020.

### (2) Effect of briefing/debriefing following neonatal resuscitation (NLS 1562: ScopRev)

CoSTR2020: Although there is emerging evidence in many fields that holding a briefing session before delivery in the delivery room and a debriefing session after resuscitation may lead to improvement in practices and outcomes, there have been no recommendations regarding briefing/debriefing in the neonatal area. A systematic review concluded that briefing and debriefing may improve the short-term outcomes of neonates and the performance of health care professionals. However, the effects of briefing and debriefing on long-term clinical outcomes and performance are not known.

NCPR2020 recommends the introduction of briefing and debriefing.

## 2 Initial assessment and intervention

### (3) Warming adjuncts (NLS 599: EvUp)

CoSTR2020: For preterm neonates < 32 weeks of gestation kept under radiant warmers in the delivery room, it is suggested that a combination of interventions be used to reduce hypothermia (< 36.0°C) on admission to the NICU, such as maintaining an environmental temperature of 23°C to 25°C, warm blankets, wrapping without drying, caps, and thermal mattresses. It is suggested that hyperthermia (> 38.0°C) be avoided due to the potential associated risks. These recommendations remain unchanged from CoSTR2010.

NCPR2015 suggested that when performing resuscitation procedures under a radiant warmer in preterm infants born between 28 and 32 weeks of gestation, a combination of interventions such as an environmental temperature of 23°C to 25°C, warm blankets, wrapping with poly-

**Table. 2** The 22 issues addressed in the CoSTR2020

| Issue | |
|---|---|
| Anticipation and preparation | |
| 1. Prediction of the need for respiratory support in the delivery room | EvUp |
| 2. Effect of briefing/debriefing after neonatal resuscitation | ScopRev |
| Initial assessment and intervention | |
| 3. Warming adjuncts | EvUp |
| 4. Suctioning of clear fluid | ScopRev |
| 5. Tracheal intubation and suctioning of nonvigorous neonates with meconium-stained amniotic fluid | SysRev |
| Physiologic monitoring and feedback devices | |
| 6. Heart rate monitoring during neonatal resuscitation | EvUp |
| Ventilation and oxygenation | |
| 7. Sustained inflation | SysRev |
| 8. Positive end-expiratory pressure (PEEP) vs. no PEEP | EvUp |
| 9. Continuous positive airway pressure (CPAP) vs. intermittent positive pressure ventilation (PPV) | EvUp |
| 10. T-piece resuscitator vs. self-inflating bag for ventilation | ScopRev |
| 11. Oxygen for the resuscitation of preterm neonates | SysRev |
| 12. Oxygen for the resuscitation of term neonates | SysRev |
| Circulatory support | |
| 13. CPR ratios for neonatal resuscitation | EvUp |
| 14. Two-thumb versus two-finger compressions for neonatal resuscitation | EvUp |
| Drug and fluid administration | |
| 15. Epinephrine (adrenaline) for neonatal resuscitation | SysRev |
| 16. Intraosseous versus umbilical vein for emergency access | SysRev |
| 17. Volume infusion during neonatal resuscitation | EvUp |
| 18. Sodium bicarbonate during neonatal resuscitation | EvUp |
| Prognostication during CPR | |
| 19. Impact of the duration of intensive resuscitation | SysRev |
| Postresuscitation care | |
| 20. Rewarming of hypothermic neonates | EvUp |
| 21. Therapeutic hypothermia in settings with limited resources | EvUp |
| 22. Postresuscitation glucose management | EvUp |

SysRev: Systematic Review, ScopRev: Scoping Review, EvUp: Evidence update

ethylene plastic wrap, and thermal mattress should be used to avoid hypothermia (< 36°C) on admission to the NICU, and whether to dry neonates before wrapping them may be determined by each institution. This recommendation is unchanged in NCPR2020.

## (4) Suctioning of clear fluid (NLS 596: ScopRev)

CoSTR2020: Routine oropharyngeal and nasopharyngeal suctioning of clear amniotic fluid as an initial treatment after delivery is not recommended. This treatment recommendation is unchanged from CoSTR2010.

The NCPR2020 also recommends against routine oropharyngeal and nasopharyngeal suctioning in neonates with clear amniotic fluid.

## (5) Tracheal intubation and suctioning of nonvigorous meconium-stained newborns (NLS 865: SysRev)

CoSTR2020: It is recommended that routine oropharyngeal and nasopharyngeal suctioning not be performed immediately after birth in nonvigorous meconium-stained neonates. These recommendations are unchanged from CoSTR2015, although the latest scoping review directly recommends against routine suctioning.

NCPR2020 recommends that routine oropharyngeal and nasopharyngeal suctioning not be performed immediately after birth in nonvigorous neonates with meconium-stained amniotic fluid, which is unchanged from NCPR2015. Meconium-stained amniotic fluid remains an important risk factor for neonates undergoing advanced resuscitation procedures in the delivery room and, though rate, intubation and endotracheal suctioning may be required to relieve airway obstruction. Therefore, it is recommended to have equipment for endotracheal intubation ready and a physician experienced in endotracheal intubation available.

## 3 Physiologic monitoring and feedback devices

### (6) Heart rate monitoring during neonatal resuscitation (NLS 898: EvUp)

CoSTR2020: It is suggested that electrocardiography (ECG) can be used for the rapid and accurate measurement of heart rate in neonates who require resuscitation. This recommendation is unchanged from CoSTR2015. However, new technologies for detecting and measuring heart rate are increasingly reported and should be compared with the current gold standard of ECG monitoring using gel electrodes in the future.

The NCPR2015 recommendation that ECG should be considered as needed remains unchanged in NCPR2020. It is desirable to use and disseminate ECG, especially in facilities that handle high-risk deliveries, such as general and regional perinatal care centers. It should also be noted that pulse oximetry can measure oxygen saturation as well as heart rate but is not a substitute for ECG. Pulse oximetry should be used during positive pressure ventilation (PPV) and in the stabilization sequence.

## 4 Ventilation and oxygenation

### (7) Sustained inflation (NLS 809: SysRev)

CoSTR2020: It is suggested that preterm neonates who require PPV due to bradycardia or ineffective breathing at birth should not routinely receive initial sustained inflation for more than 5 s.

NCPR2015 also recommended against sustained inflation for more than 5 s in preterm neonates without spontaneous breathing at birth because there was insufficient evidence to recommend sustained inflation and because the methods of application and assessment of effectiveness were not clearly defined. This recommendation is unchanged in NCPR2020.

### (8) Positive end-expiratory pressure (PEEP) vs. no PEEP (NLS 897: EvUp)

CoSTR2020: It is recommended that PEEP be used for the initial ventilation of preterm neonates during resuscitation. For term neonates, there is insufficient data to make a recommendation. This recommendation is unchanged from CoSTR2015.

The NCPR2015 recommendation that PEEP of 5 cm $H_2O$ be used for the initial ventilation of preterm neonates remains unchanged in NCPR2020.

### (9) Continuous positive airway pressure (CPAP) vs. intermittent positive pressure ventilation (PPV) (NLS 590: EvUp)

CoSTR2020: For preterm neonates with labored breathing, it is recommended that CPAP be introduced first, rather than performing PPV or endotracheal intubation immediately. This recommendation is unchanged from CoSTR2010.

NCPR2015 recommended that preterm and term neonates with labored breathing should receive CPAP first, if available, rather than immediately undergoing PPV or endotracheal intubation. This recommendation remains unchanged in NCPR2020.

### (10) T-piece resuscitator vs. self-inflating bag for ventilation (NLS 870: ScopRev)

CoSTR2020: There is insufficient evidence to recommend the use of either a T-piece resuscitator or a self-inflating bag as the device for administering PPV at birth, and therefore, the recommendation of one device over another would be purely speculative. This recommendation is unchanged from CoSTR2010. However, a recent randomized controlled trial with a sufficient sample size and a large observational study have shown that the use of a T-piece resuscitator improves survival, reduces intubation rates, and decreases the incidence of chronic lung disease, suggesting the need to conduct a formal SysRev in the near future.

NCPR2020 also does not recommend the use of any specific device. In Japan, self-inflating and flow-inflating resuscitation bags are mainly used, and the adoption rate of T-piece resuscitators is low. Each medical institution should select an appropriate device based on an understanding of the advantages and disadvantages of each device and should provide sufficient training to their staff to ensure their capability for providing effective ventilation immediately.

### (11) Oxygen for preterm resuscitation (NLS 864: 2019 CoSTR publication) [4)]

CoSTR2020: For preterm neonates < 35 weeks of gestation who receive respiratory support at birth, it is recommended to start with a low oxygen concentration (21-30%) rather than higher oxygen concentration (60-100%). An oxygen concentration range of 21-30% is recommended because all trials used this range for the low oxygen concentration group. Once oxygenation is started, it is recommended that a pulse oximeter be used to adjust the oxygen concentration. This recommendation is unchanged from CoSTR2015.

In NCPR2020, as in NCPR2015, it is recommended to start with a low oxygen concentration (21-30%) rather than a higher oxygen concentration (60-100%) for preterm neonates < 35 weeks of gestation who receive respiratory support at birth.

### (12) Oxygen for term resuscitation (NLS 1554: 2019 CoSTR publication) [4)]

CoSTR2020: For neonates ≥ 35 weeks of gestation receiving respiratory support at birth, it is recommended to start with 21% oxygen (air). Starting with 100% oxygen is not recommended. This recommendation is unchanged from CoSTR2015. In NCPR2020, as in NCPR2015, it is recommended to start with 21% oxygen (air) for neonates ≥ 35 weeks of gestation receiving respiratory support at birth.

## 5 Circulatory support

### (13) CPR ratios for neonatal resuscitation (NLS 895: EvUp)

CoSTR2020: It is recommended that a 3:1 compression-to-ventilation ratio be used for NCPR. This recommendation is unchanged from CoSTR2015.

In NCPR2020, as in NCPR2015, it is recommended that a 3:1 compression-to-ventilation ratio be used for NCPR.

### (14) Two-thumb versus two-finger compressions for neonatal resuscitation (NLS 605: EvUp)

CoSTR2020: It is recommended that chest compressions in neonates be performed using the two-thumb, hands-encircling-the-chest method. This recommendation is unchanged from CoSTR2015.

In NCPR2020, as in NCPR2015, it is recommended that the two-thumb, hands-encircling-the-chest method be used as the first-line approach for chest compressions in neonates. In situations where the two-thumb method cannot be used, the use of the two-finger method is recommended.

## 6 Drug and fluid administration

### (15) Epinephrine (adrenaline) for neonatal resuscitation (NLS 593: SysRev)

CoSTR2020: If the heart rate has not increased to 60 bpm or greater after optimizing ventilation and chest compressions, the intravascular administration of adrenaline (0.01-0.03 mg/kg) is recommended. If vascular access cannot be established, it is recommended to administer endotracheal adrenaline at a higher dose (0.05-0.1 mg/kg) than that used for IV administration, although this should not delay attempts to establish vascular access after endotracheal adrenaline administration. If the heart rate remains below 60 bpm, it is suggested to administer adrenaline every 3 to 5 min, preferably intravascularly. If the response is inadequate, it is suggested to administer intravascular adrenaline as soon as vascular access is established, regardless of the interval from the initial endotracheal dose. This recommendation contains more specific dosage information and guidance on repeated dosing than the CoSTR2010 recommendation.

NCPR2020 also recommends that adrenaline be administered into the umbilical vein if the heart rate has not increased to 60 bpm or higher after optimizing ventilation and chest compressions. If vascular access cannot be established, endotracheal administration is the second-line option. It is recommended that endotracheal adrenaline be administered at a higher dose than that used for IV administration. If the heart rate does not improve with the endotracheal administration of adrenaline, an attempt to establish vascular access should not be delayed. If the heart rate remains below 60 bpm, adrenaline should be administered every 3 to 5 min via the same route of administration. If the response to endotracheal adrenaline is inadequate, it is suggested to administer intravascular adrenaline as soon as vascular access is established, regardless of the interval from the initial endotracheal dose. This recommendation remains unchanged from NCPR2015 in terms of the dosage or repeat-dose interval by the same route, but it emphasizes the importance of the IV administration of adrenaline. It is suggested that pediatricians who perform resuscitation prepare equipment for securing umbilical venous access so that IV adrenaline can be administered when necessary and that they receive prior training so that umbilical venous access can be established promptly. However, in Japan, peripheral venous access is still used as an alternative to umbilical venous access. Peripheral access may be used as the first choice of administration route if it can be reliably secured in a time frame similar to that of umbilical access.

### (16) Intraosseous (IO) versus umbilical vein for emergency access (NLS 616: SysRev)

CoSTR2020: Umbilical venous catheterization is recommended as the first choice for vascular access during neonatal resuscitation in the delivery room. If umbilical venous access is not feasible, then the IO route is a reasonable alternative. When performing resuscitation outside the delivery room, it is suggested that either umbilical venous access or the IO route be used for drug or fluid administration. The actual route used will depend on the equipment, training, and experience available at each institution. CoSTR2010 stated that during neonatal resuscitation, the IO route can be used for drug and fluid administration on a temporary basis only when umbilical venous access has failed or when a health care professional skilled at securing IO access is available. Given the extensive reports of complications with the IO route, the CoSTR2020 more strongly favors the umbilical venous route for resuscitation performed in the delivery room but continues to allow the IO route to be used in some situations.

In NCPR2020, as in NCPR2015, it is stated that if a physician skilled at securing IO access for fluid infusion with a bone marrow needle is available, IO administration with a bone marrow needle may be performed if umbilical venous access cannot be established.

### (17) Volume infusion during neonatal resuscitation (NLS 598: EvUp)

CoSTR2020: Early volume replacement with saline solution or packed red blood cells is indicated for bleeding neonates who are unresponsive to resuscitation. There is insufficient evidence to support the routine use of circulatory volume expanders in nonbleeding neonates who are unresponsive to ventilation, chest compressions, or adrenaline. Because of the possibility of occult bleeding, the trial use of circulatory volume expanders may be considered for neonates who are unresponsive to resuscitation. These treatment recommendations are unchanged from CoSTR2010.

In NCPR2020, as in NCPR2015, it is stated that volume expansion with saline solution may be considered for neonates with a history of premature placental abruption, placenta previa, umbilical cord hemorrhage, fetomaternal transfusion syndrome, or twin-twin transfusion syndrome and neonates for with unknown medical history who are unresponsive to appropriate resuscitation due to hypovolemic shock caused by an obvious drop in circulatory blood volume. For neonates with suspected anemia since the fetal stage, the administration of type-O Rh-negative packed red blood cells should be considered.

### (18) Sodium bicarbonate during neonatal resuscitation (NLS 606: EvUp)

CoSTR2020: Sodium bicarbonate administration is not recommended during brief CPR but may be useful during prolonged cardiac arrest after adequate ventilation is established if there is no response to other therapies. This recommendation is unchanged from CoSTR2010.

In NCPR2020, as in NCPR2015, it is recommended that sodium bicarbonate administration be considered when a neonate has obvious metabolic acidosis despite adequate ventilation management and the acidosis appears to be preventing the improvement of hemodynamics.

## 7 Prognostication during CPR

### (19) Impact of duration of intensive resuscitation (NLS 896: SysRev)

CoSTR2020: Failure to achieve the return of spontaneous circulation in neonates despite 10-20 min of intensive resuscitation is associated with a high risk of mortality and a high risk of moderate to severe neurodevelopmental impairment among survivors. However, there is no evidence that any specific duration of resuscitation consistently predicts mortality or moderate to severe neurodevelopmental impairment. If, despite all recommended resuscitation procedures, including ventilation with oxygen, chest compressions, and adrenaline administration and the exclusion of all possible reversible causes, a neonate requires ongoing CPR, it is suggested that the discontinuation of resuscitation efforts be discussed with the clinical team and the patient's family. A reasonable time frame in which to consider this change in the goals of care is approximately 20 min after birth.

NCPR2015 stated that although neonatal resuscitation may be discontinued if the Apgar score remains at 0 for more than 10 min in a near-term or term neonate, recent reports that some neonates with an Apgar score of 0 for 10 min have survived without disability after receiving therapeutic hypothermia indicate that the decision should be individualized and should consider factors such as whether resuscitation was performed appropriately; the availability of intensive care approaches, such as therapeutic hypothermia; the timing of the insult before delivery; and the wishes of the family. Unlike NCPR2015, NCPR2020 provides guidance for "considering discontinuation" rather than "discontinuing" resuscitation; in particular, it suggests that the discontinuation of resuscitation efforts should be discussed with the patient's family if the return of spontaneous circulation is not achieved after 20 min of resuscitation with ventilation, chest compressions, and adrenaline administration. However, decisions regarding whether to continue resuscitation should be made on a case-by-case basis and should consider factors such as the number of weeks of gestation, the presence or absence of congenital anomalies, the timing of perinatal injury, the appropriateness of the resuscitation interventions, the wishes and values of the family, the availability of postresuscitation resources (e.g., neonatal intensive care) after the return of spontaneous circulation, and the availability of neuroprotective strategies such as therapeutic hypothermia.

## 8 Postresuscitation care

### (20) Rewarming of hypothermic newborns (NLS 858: EvUp)

CoSTR2020: A recommendation cannot be made for either rapid rewarming (> 0.5°C/h) or slow rewarming (< 0.5°C/h) for unintentionally hypothermic neonates (body temperature < 36°C). This recommendation is unchanged from CoSTR2015.

This recommendation remains unchanged from NCPR2015 to NCPR2020.

### (21) Induced hypothermia in settings with limited resources (NLS 734: EvUp)

CoSTR2020: It is suggested that therapeutic hypothermia be performed for term or near-term neonates with moderate to severe hypoxic-ischemic encephalopathy, even in low-income countries and/or other resource-limited settings. Therapeutic hypothermia should be considered and conducted under clearly defined protocols only in neonatal care facilities with intensive care capabilities and adequate resources to provide intravenous therapy, respiratory support, monitoring with pulse oximetry or other technologies, antimicrobial therapy, anticonvulsive therapy, and laboratory tests. The protocol is the same as that used in randomized controlled trials, that is, cooling to commence within 6 h, strict temperature control from 33°C to 34°C for 72 h, and rewarming over at least 4 h.

Although this recommendation does not apply to Japan, where systems are in place to provide therapeutic hypothermia according to standard protocols, some NCPR instructors have the opportunity to participate in the development of neonatal resuscitation systems and educational efforts regarding resuscitation in developing countries. Therefore, the concept described in CoSTR2020 is reflected in NCPR2020.

### (22) Postresuscitation glucose management (NLS 607: EvUp)

CoSTR2020: Intravenous glucose infusion should be considered as soon as possible after resuscitation, with the goal of avoiding hypoglycemia. This recommendation is unchanged from CoSTR2010.

In NCPR2020, as in NCPR2015, it is recommended that in neonates at high risk of hypoxic ischemia due to neonatal asphyxia, blood glucose should be measured after resuscitation, and prompt intervention, including intravenous glucose administration, should be considered if hypoglycemia is present.

# III Flow of the algorithm

## 1 Importance of briefing

In resuscitation, the performance of the team is important, as are the skills of each individual. It is recommended that team members conduct briefings to confirm the use of infection control measures, the availability of resuscitation supplies, and role assignments.

## 2 Neonatal assessments made immediately after birth

In NCPR2020, as in NCPR2015, it is recommended to check for (1) preterm gestation, (2) weak breathing or crying, and (3) weak muscle tone immediately after birth.

## 3 Routine care

If the neonate does not meet any of the three criteria, routine care consisting of (1) providing warmth, (2) ensuring an open airway, (3) drying, and (4) ongoing evaluation should be performed while having the neonate stay with the mother to promote bonding.

## 4 Initial steps of resuscitation

If there is abnormality in any of the three assessment items immediately after birth, initial resuscitation procedures should be initiated. In NCPR2010, “meconium-stained amniotic fluid” was excluded from the assessment items used to determine the need for resuscitation procedures at birth. Therefore, routine tracheal suctioning is no longer necessary, even for nonvigorous neonates with meconium-stained amniotic fluid.

CoSTR2020 again addressed this issue and decided to continue to adopt the 2010 recommendation, although the recommendation against suctioning has been strengthened.

For neonates who are apneic or have a heart rate of less than 100 bpm, initial resuscitation procedures should be initiated so that ventilation can be started within 60 s of birth (i.e., provide warmth and maintain the body position to ensure an open airway; if necessary, open the airway, wipe away fluid, stimulate the skin, and reposition the neonate to ensure an open airway). Approximately 30 s should be allocated for initial resuscitation procedures. However, this does not necessarily mean that the initial procedures should be continued for 30 s; rather, the initial procedures should be conducted properly to prevent hypothermia, open the airway, and introduce effective ventilation.

## 5 Evaluation after initial steps of resuscitation

After the initial resuscitation procedures, as in NCPR2015, it is recommended that a generally effective intervention be performed for 30 s, followed by the assessment of respiration and heart rate.

The utilization of pulse oximeters is unchanged from NCPR2015. In the lifesaving sequence, it is recommended to consider attaching a pulse oximeter probe to the neonate’s right hand and using an ECG monitor.

## 6 Ventilation

The importance of initiating effective ventilation without delay remains the same in NCPR2020 as in NCPR2015. The recommendation that ventilation with air be performed if apnea continues or the heart rate remains below 100 bpm despite initial resuscitation procedures in term or preterm neonates ≥ 35 weeks of gestation at the initiation of ventilation is also unchanged. If there is no increase in heart rate or improvement in oxygenation, as indicated by pulse oximetry, despite effective ventilation, the use of oxygen should be considered. However, if the heart rate is above 100 bpm and oxygen saturation is increasing, there is no need to administer oxygen immediately.

## 7 Chest compressions

The recommendation that chest compressions be performed when bradycardia (less than 60 bpm) persists after 30 s of effective ventilation is unchanged from NCPR2015. The compression-to-ventilation ratio should be 3:1, with each cycle lasting 2 s. For chest compressions, it is recommended that the two-thumb, hands-encircling-the-chest method be used, and the lower third of the sternum should be compressed to a depth of one-third of the anteroposterior diameter of the chest.

The oxygen concentration during chest compressions does not necessarily have to be as high as ≥ 80%, but oxygen must be administered. If the heart rate is above 100 bpm and oxygen saturation is 95% or higher, the oxygen concentration should be lowered promptly.

## 8 Medications

In NCPR2020, as in NCPR2015, it is stated that chest compressions and ventilation should not be interrupted to administer adrenaline if the heart rate is below 60 bpm despite the combination of chest compressions and ventilation. The recommendations remain unchanged in terms of the administration route and dosage, although CoSTR2020 more strongly recommends the umbilical vein as the route of drug administration. However, in Japan, peripheral venous routes are also routinely used in many institutions, and each institution should establish its own policy for venous route selection. If the patient enters the lifesaving sequence, it is desirable to have at least three personnel available so that adrenaline can be administered without interrupting effective ventilation and chest compressions. Therefore, efforts should be made to gather personnel as early as possible.

The intravenous administration of circulatory volume expanders such as saline solution, which was previously recommended in cases of poor response to resuscitation, is now indicated only in cases of suspected blood loss.

# 9 Oxygenation

Since NCPR2010, it has been strongly recommended that pulse oximetry be used during the resuscitation of an asphyxiated neonate to avoid overoxygenation. This recommendation remains unchanged in NCPR2020. Especially in institutions that frequently treat high-risk neonates, it is recommended that oxygen blenders and pulse oximeters always be available in the delivery room and that the minimum necessary amount of oxygen be administered while monitoring $SpO_2$.

If, after initial resuscitation procedures, the heart rate is above 100 bpm and spontaneous breathing is well established but labored breathing or central cyanosis is present, it is recommended that a pulse oximeter be attached to the neonate's right hand and that continuous positive airway pressure (CPAP) with room air or free-flow oxygenation be introduced if necessary.

# 10 Postresuscitation management

## (1) Therapeutic hypothermia

NCPR2015 recommended that term or near-term (36 weeks of gestation) neonates with moderate to severe hypoxic-ischemic encephalopathy should be treated with therapeutic hypothermia (33.5-34.5°C) for 72 h starting within the first 6 h of life, followed by rewarming over at least 4 h.

The recommendation remains unchanged in NCPR2020 in terms of indications and protocol.

## (2) Blood glucose management

NCPR2020 follows the recommendations of NCPR2015. In neonates at high risk of hypoxic ischemia due to neonatal asphyxia, blood glucose should be measured after resuscitation, and prompt intervention, including intravenous glucose administration, should be considered if hypoglycemia is present.

# 11 Considering discontinuation of resuscitation

CoSTR2010 contains only a general statement that "it is reasonable to withhold resuscitation when early death or an unacceptably severe outcome is almost certainly predicted based on the length of gestation, birth weight, and congenital anomalies."

In NCPR2015, it is stated that although resuscitation may be discontinued if the Apgar score remains at 0 for more than 10 min in a term or near-term neonate, recent reports that some neonates with an Apgar score of 0 for 10 min have survived without disability after receiving therapeutic hypothermia indicate that the decision should be individualized and should consider factors such as whether resuscitation was performed appropriately; the availability of intensive care methods, such as therapeutic hypothermia; the timing of the insult before delivery; and the wishes of the family.

NCPR2020 recommends that the discontinuation of resuscitation be considered if the Apgar score remains at 0 for more than 20 min despite adequate ventilation, chest compressions, and adrenaline administration in all neonates. This 20-min duration is based on the fact that the series of procedures leading up to adrenaline administration takes approximately 20 min.

# 12 Other

## (1) Timing of cord clamping in term and near-term neonates

Japanese people have significantly higher transcutaneous bilirubin levels than Caucasians, resulting in a higher incidence of jaundice. This is attributable to a higher prevalence of race-associated gene mutations in bilirubin uridine diphosphate glucuronosyltransferase. [5,6]

Against this background, NCPR2020 continues to withhold the recommendation of delayed cord clamping for term or near-term neonates because "there is insufficient evidence to support or refute delayed cord clamping in Japan" and because of concerns that the introduction of delayed cord clamping may increase the need for phototherapy and consequently prolong the hospitalization of neonates.

## (2) Timing of cord clamping in preterm neonates

CoSTR2020 follows NCPR2015 because no SysRev was available at the time and recommends, albeit weakly, that cord clamping be delayed for at least 30 s in preterm neonates as doing so reduces the frequency of serious complications such as intraventricular hemorrhage and necrotizing enterocolitis, although it may increase the risk of jaundice. In Japan, one-time umbilical cord milking after cord clamping and disconnection appears to be a reasonable intervention for preterm neonates who require resuscitation.

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Chapter
2

# Basic Neonatal Resuscitation

Chap.2

# Basic knowledge for neonatal resuscitation

A firm grasp of the major anatomical and pathophysiological concepts that form the foundation of neonatal resuscitation facilitates understanding the various conditions that can arise in the process and enables care providers to proceed efficiently. This section provides a concise explanation of the necessary anatomy and pathophysiology.

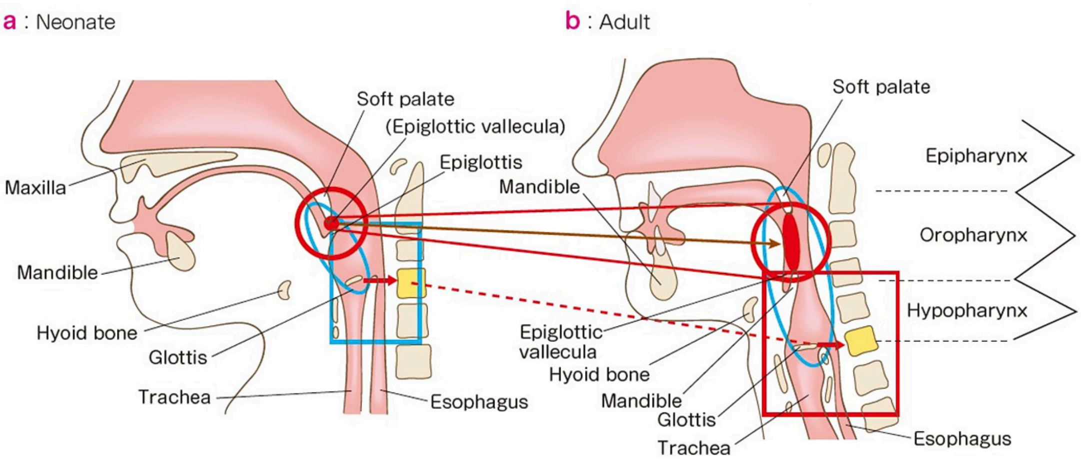
## I Anatomical knowledge for neonatal resuscitation

### 1 Anatomy of the upper respiratory tract and changes with age

The anatomy of the upper respiratory tract of the neonate, particularly from the pharynx and larynx to the trachea, changes with gestational age. The structure of in term neonates differs from that in children and adults (**Fig. 0-1**). The biggest difference in neonates is the laryngeal position.

The most important anatomical difference between neonates and adults is position of the larynx. In neonates, the area corresponding to the oropharynx is almost nonexistent because of the high position of the larynx. The larynx in neonates is located at C3 or C4 and with

**Fig. 0-1** Comparative anatomy of neonates and adults' airways




(Adapted from Arvedson, Lefton-Greif: Pediatric videofluoroscopic swallow studies, Communication Skill Builders, Texas, 1998) development descends to a position corresponding to C5 till it reaches C7 in adulthood. In summary, the position of the larynx gradually becomes lower as the body develops.

The high position of the larynx during the neonatal period indicates that the epiglottis of the neonate is also high, which places the epiglottis very close to the soft palate. This anatomical feature causes neonate to breathe primarily through the nose rather than the mouth.

Therefore, as nasal airway management is essential in establishing respiration during neonatal resuscitation, emphasis must be placed on nasal aspiration. In addition, while in endotracheal intubation in adults the epiglottis is lifted by placing the end of the blade on the epiglottic vallecular, in neonate it is lifted directly with a straight blade.

## 2 Anatomy of the lower respiratory tract and changes with age

During the fetal period, the lungs mature in four stages (**Fig. 0-2**). As long as there are no substantial problems during pregnancy, the lungs of a term neonate are mature enough to adapt to extrauterine life.

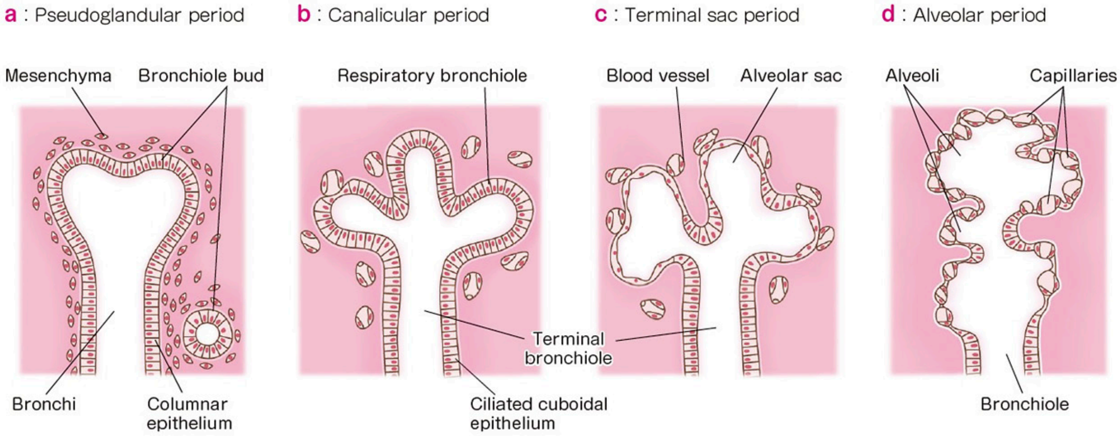
**a. Pseudoglandular period: Weeks 5 to 16 of gestation (differentiation of terminal bronchioles).**

Preterm infants born during this period cannot survive because they are unable to breath independently.

**b. Canalicular period: Weeks 16 to 26 of gestation (partial differentiation of alveoli)**

Cuboidal primordial alveoli differentiate into squamous alveolar epithelial cells as they are surrounded by capillaries. Preterm infants born after week 21 are capable of respiration and can sometimes survive. Therapies that are considered effective include surfactant therapy and glucocorticoid therapy.

**Fig. 0-2** Histogenesis of the fetal lungs



**c. Terminal sac period: Week 26 of gestation to birth.**

The formation and maturation of the alveoli progresses.

**d. Alveolar period: 0 to approximately 10 years**

The number of alveoli increases from birth to approximately 10 years of age.

When a term neonate is born, lung fluids are replaced with air upon crying, and respiration is established when most of the alveoli are filled with air. However, caution is required for preterm neonates because depending on lung maturity, respiration may not be established even after lung fluids are replaced with air. Endotracheal intubation and medications (e.g., surfactants) may sometimes be required.

# II Respiratory and circulatory physiology at birth

## 1 From fetal circulation to birth and first breath

Before birth, in utero, the fetal lungs are inflated and filled with lung fluid without collapsing. Intrauterine exchange of substances takes place with the mother via the placenta until the onset of gas exchange by "pulmonary respiration" after the first breath. Oxygen is also supplied through the placenta and diffuses into the fetal blood.

Gas exchange occurred in the placenta; maternal blood flows into the uterine arteries, spiral arteries, and intervillous spaces on the maternal side, and umbilical cord blood flows into the umbilical arteries and intravillous capillaries on the fetal side. Maternal and fetal complications and diseases are involved in each blood flow, which greatly affect fetal growth.

Unlike in adults, in the fetus, most hemoglobin is hemoglobin F, which has a higher affinity to oxygen. This allows higher oxygen saturation in the fetal blood, even though the partial pressure of oxygen in fetal blood is lower than in maternal blood. When the partial pressure of oxygen is higher in maternal blood, oxygen moves to fetal blood from maternal blood by simple diffusion. Even when the partial pressure of oxygen is similar in both the mother and the fetus, the oxygen content of the arterial blood and the oxygen supply to the peripheral tissues are maintained in fetuses because fetal hemoglobin, which is present in high concentrations, becomes more saturated with oxygen.

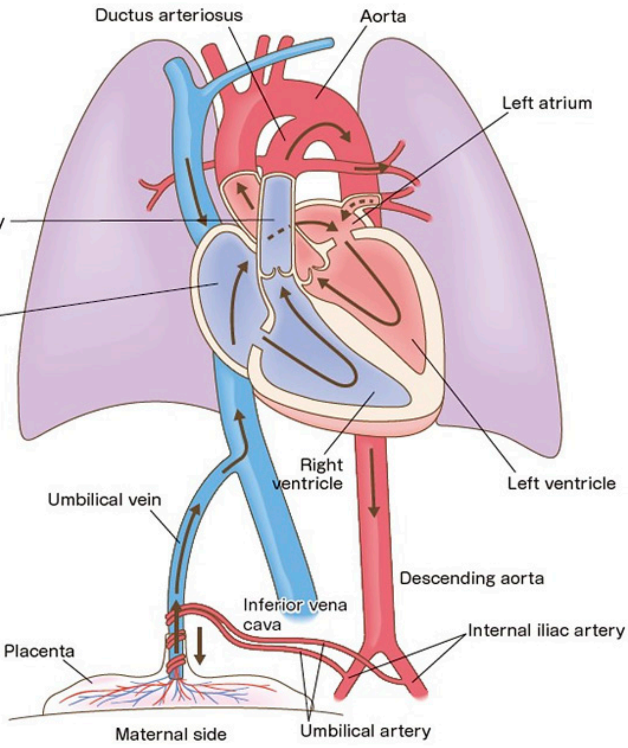
## 2 Fetal circulation

Fetal blood, upon receiving oxygen at the placenta, flows from the inferior vena cava into the right atrium via the umbilical vein. Thus, this part of the fetal-placental system has the highest partial pressure of oxygen. Here, the blood mixes with returning fetal systemic blood from the inferior vena cava and superior vena cava. Because the pressure is higher in the right atrium than in the left atrium, most of the blood that flows from the inferior vena cava into the right atrium reaches the left atrium through the foramen ovale and then flows into the left ventricle, while most of blood from the superior vena cava, which has a low partial pressure of oxygen, flows into the right ventricle from the right atrium.

Blood is ejected from the right ventricle to the pulmonary artery, but only a small portion of this blood flows into the fetal lungs. Arterioles that perfuse the fetal lungs are contracted mainly because of the low partial pressure of oxygen. This results in extremely high pulmonary vascular resistance, and consequently, most of the blood ejected from the right ventricle cannot perfuse the lungs; instead, it flows towards the aorta through the ductus arteriosus, which is a low-resistance bypass between the aorta and the pulmonary artery.

Meanwhile, blood that enters the left atrium flows into the left ventricle to reach the upper body through the ascending aorta. It then joins the blood from the right ventricle, which passes through the ductus arteriosus, to reach whole body (**Fig. 0-3**). Because of these fetal hemodynamics, major circulatory disorders do not commonly occur, even in the presence of a heart defect.

**Fig. 0-3** Overview of the fetal circulatory system



# 3 Adaptations at birth and first breath

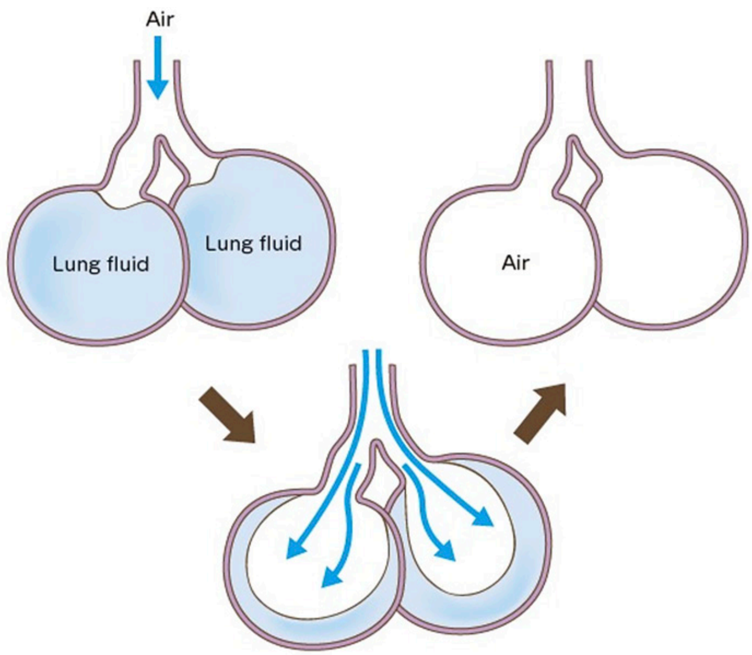
Why the first breath occurs remains an unsolved mystery. It is extremely important that fetal alveoli are filled with lung fluids and remain expanded in the uterus because this facilitates adaptation to pulmonary respiration and the rapidly changing environment after birth.

With onset of the first breath, the inhaled air fills the alveoli as the fluids in the alveoli are absorbed by blood vessels and lymph vessels in the lung tissues. The negative pressure in the lungs, which is said to reach –100 $cmH_2O$, causes them to instantaneously expand. Approximately one-third of the fluids in the alveoli move to the oral cavity, while the remainder quickly moves into the lung tissue.

Air contains 21% oxygen, which can diffuse into the blood vessels around the alveoli (**Fig. 0-4**). Absorption is facilitated by the low protein concentration in the lung fluids. Furthermore, the absorption of lung fluids is facilitated by catecholamine, which begins to be secreted in the fetus soon after the onset of labor pains and is stimulated by the stress of labor.

As the alveoli expand with air and the partial pressure of oxygen increases, pulmonary blood vessels that were contracted become relaxed. Thus, resistance decreases, and systemic blood pressure increases, causing pulmonary blood flow to increase dramatically. This leads to decreases in blood flow through the ductus arteriosus and the uptake of oxygen by blood vessels around the alveoli. Then, blood with a high partial pressure of oxygen flows into the left atrium through the pulmonary vein to enter the systemic circulation.

**Fig. 0-4** Changes in alveoli that occur with the first breath



With the first breath after birth, the umbilical artery and vein and ductus venosus, which have been used for the exchange of gases and other substances, contract, and the blood flow through them is halted. This is the end of the placental circulation with extremely low vascular resistance. Consequently, the fetal blood pressure rises.

## 4 Role of the ductus arteriosus

The partial pressure of oxygen increase once pulmonary respiration has started, and the ductus arteriosus begins to contract as the pulmonary blood vessels relax. As neonates adapt to pulmonary respiration, the skin of their chest area turns pink, and the pinkness spreads to the trunk and then to the limbs. These drastic changes occur within several minutes of birth, although approximately 10 min is likely to be required before the preductal oxygen saturation exceeds 90% in term neonates. Even more time is required before the postductal oxygen saturation exceeds 90%.

Increases in left atrial pressure due to increases in left atrial perfusion, and decreases in the right atrial pressure due to decreases in pulmonary vascular resistance, cause the functional closure of the foramen ovale, which is believed to occur within several minutes after birth.

Furthermore, the ductus arteriosus functionally closes 12-24 h after the blood flow is halted, and anatomical closure occurs thereafter. Although pulmonary vascular resistance drops suddenly as the pulmonary vasculature relaxes, it takes several months for the resistance to completely decrease and stabilize. When the pulmonary circulation involving the right heart and the systemic circulation involving the left heart, which are independent of each other, are established, the transition to adult circulation is complete. The ductus arteriosus plays an essential role in fetal circulation, in which gas exchange does not take place in the lungs, but this role ends when neonates adapt to extrauterine circulation; adult circulation is established after the complete closure of the ductus arteriosus.

## 5 Establishment of pulmonary respiration

When the body transitions to pulmonary respiration, the lungs must maintain functional residual capacity to resist the high surface tension and ensure that they do not collapse once they expand. If functional residual capacity is maintained, the alveoli can expand with slight negative pressure, and lung surfactant forms layers at air/water interfaces in the alveolar space to resist this surface tension.

Anatomically, physiological dead space is larger compared to the alveolar volume.In addition, because of low tidal volume, ventilation occurs at a respiratory rate of 40 to 50 breaths per minute, many times that of adults.

Neonates frequently exhibit irregular respiratory patterns and sometimes stop physiological respiration momentarily. Term infants and near-term infants exhibit periodic breathing, in which they pause their breathing for a period of several seconds to approximately 10 s and then start breathing again. In addition, neonate respiration is primarily nasal, and it takes several months for respiration through the mouth to be established. Therefore, nasal continuous positive airway pressure (CPAP) therapy to prevent lung collapse is used to treat disorders associated with alveolar collapse in neonates (e.g., apnea and respiratory distress syndrome).

(Isao Kusakawa)

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# Indications for neonatal resuscitation



According to the medical definition, a neonate or newborn is a child under 28 days of age. The difference between neonatal and pediatric CPR has been distinct from Consensus 2010 onward. This distinction could conceivably cause confusion when performing CPR on an infant younger than 1 month of age. As it is of the highest importance to avoid hesitation or delay in the initiation of CPR due to excessive concern about whether the patient is technically a neonate or child, CPR for infant should be approached as follows.

- Resuscitation in the delivery room or nursery and of infants (corrected age <1 month) admitted to the NICU should be performed in NCPR.
- In emergency resuscitation during prehospital care, in a pediatric ward, or in a pediatric intensive care department or other ward or outpatient department, Pediatric basic life support (PBLS) can be applied for cardiac arrest in infants younger than 28 days of age. It is important that individual facilities and groups thoroughly discuss in advance whether to follow PBLS or NCPR when resuscitating an infant and decide on a unified policy.

(Takahiro Sugiura)

Chap.2

# NCPR algorithm

## I The NCPR algorithm

The NCPR algorithm is shown in **Figure 0-5**.

Basics of the algorithm

- The NCPR algorithm is composed of assessments of the neonate's status (◇) and interventions based on the assessment results (▭).
- The neonate's status must be assessed after approximately 30 s of effective intervention.
- Move only to the step immediately before or after the current step.

### Flow diagram of the algorithm

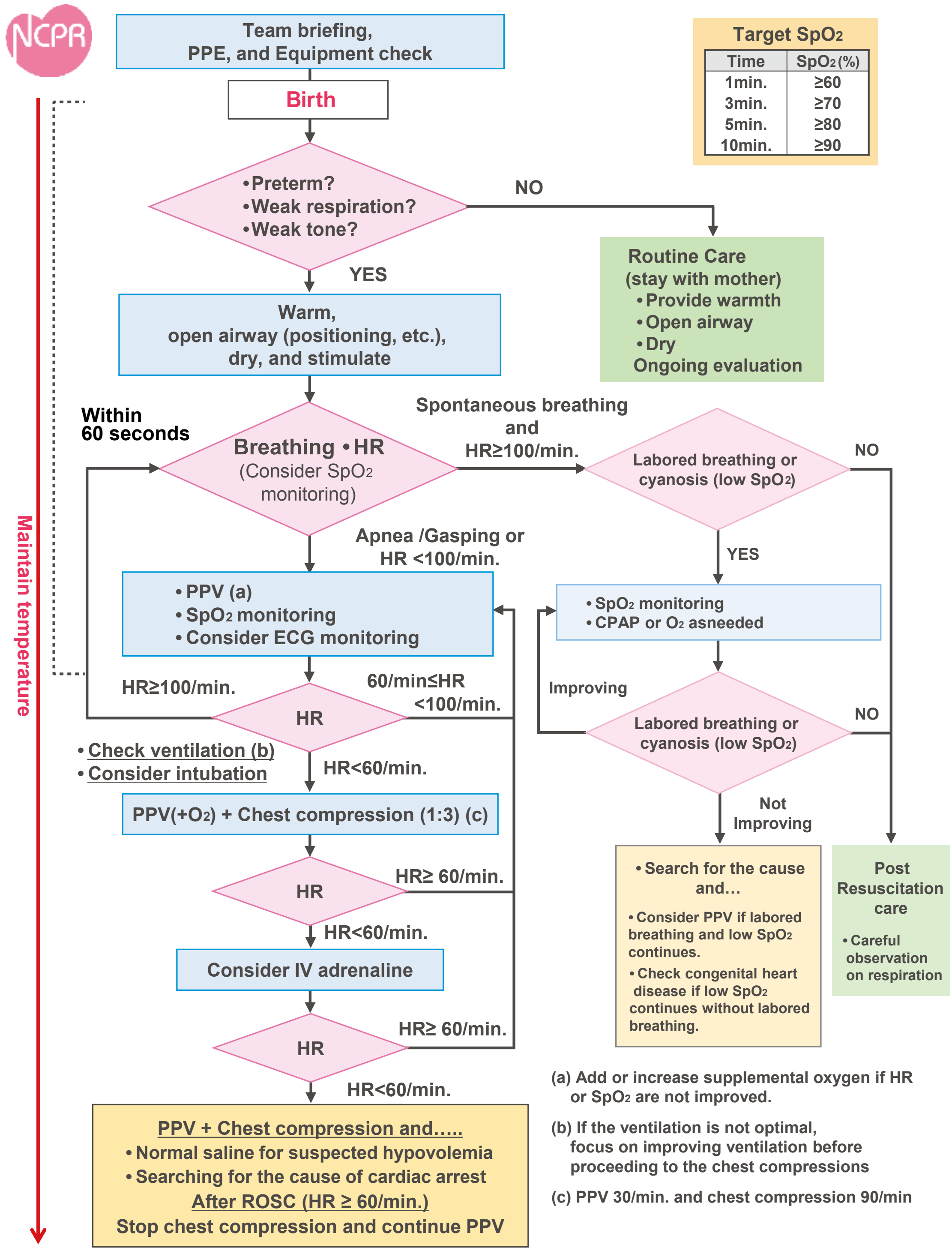
#### (1) Team briefing

In a team briefing held to improve team performance, it is important to share the anticipated risks of the neonate during resuscitation to ensure that there are sufficient supplies, ascertain that every member knows his or her role according to the risk, and share the infection status of the mother and fetus to prevent horizontal infections from them to medical professionals. Conventionally, the main component of infection control measures is the prevention of contact transmission, but during the COVID-19 pandemic, the prevention of droplet transmission has become crucial, thus increasing the significance of the team briefing.

#### (2) Moving forward along the resuscitation sequence

- Examine the following three criteria to determine whether the neonate requires resuscitation immediately after birth: (1) preterm, (2) weak breathing/crying, and (3) weak muscle tone. If none of these criteria are met, move the neonate onto the mother's chest or to a radiant warmer to provide routine care. If at least one criterion is met, follow the resuscitation sequence and start the initial steps.
- Complete the initial steps and assess two vital signs (breathing and heart rate) approximately 30 s after completion. If the neonate is breathing spontaneously and the heart rate is ≥100 bpm, assess two indicators, namely, labored breathing and central cya-

**Fig. 0-5** NCPR2020 Algorithm




(a) Add or increase supplemental oxygen if HR or $SpO_2$ are not improved.

(b) If the ventilation is not optimal, focus on improving ventilation before proceeding to the chest compressions

(c) PPV 30/min. and chest compression 90/min nosis (poor oxygen saturation). If at least one of them is observed, attach the probe of a pulse oximeter to the neonate's right hand and determine the need for respiratory support.

- If the neonate is not breathing spontaneously or is gasping, or if the heart rate is <100 bpm after completion of the initial steps, initiate ventilation and attach a pulse oximeter to the neonate. The heart rate must be measured, even if the neonate is not breathing spontaneously. If multiple medical professionals are in charge of the neonate's care, one must initiate ventilation, and another must assess the heart rate. An increase in heart rate is the most sensitive indicator of the effectiveness of ventilation; therefore, pre-ventilation assessment of the heart rate is important and necessary for comparison purposes. Additionally, consider the use of an ECG monitor at this stage. When performing ventilation, assess the neonate's chest movements as well as the heart rate to judge the effectiveness of ventilation. Even if the heart rate is <60 bpm, initiate only ventilation first, without chest compressions.
- Approximately 30 s after initiating ventilation, assess the heart rate while continuing ventilation. If the heart rate is <60-100 bpm, assess whether ventilation is being appropriately performed; if ventilation is being performed appropriately, continue ventilation with an increased oxygen concentration. If high pressure is required, consider performing endotracheal intubation. If the heart rate remains <60 bpm even after ventilation is appropriately performed, chest compressions should be started in conjunction with ventilation using a high oxygen concentration.
- If the heart rate remains <60 bpm even after ventilation with oxygen and chest compressions are performed in a coordinated manner for ≥30 s, proceed to the adrenalin administration step.
- If the heart rate still remains <60 bpm at 30 s after adrenalin administration, proceed to the next step and search for causes. If the circulating blood volume is expected to be low due to hemorrhage, consider administering a drug to address this issue. If the heart rate remains <60 bpm after that, administer adrenalin every 3-5 min.
- Perform each procedure for 30 s, assess its effectiveness, and then determine whether to proceed to the next step. If the preceding step is not completed effectively, the next step cannot be started. Therefore, the time frame of 30 s is not an absolute rule. For example, chest compressions must not be started after 30 s of ventilation if the ventilation was not appropriately performed.
- The time frame of "within 60 s" shown in the algorithm is a guideline to ensure the initiation of necessary ventilation without delay for neonates. In other words, if the airway is open and responses

to stimuli are assessed to quickly determine the need for ventilation in the initial steps, care providers do not necessarily have to continue those processes for 30 s. It is most important that ventilation be initiated by 60 s after birth at the latest.

### (3) Moving backward to the previous step in the resuscitation sequence

- After ventilation is initiated, assess the heart rate while performing ventilation. If the heart rate is ≥100 bpm, assess whether the neonate is breathing spontaneously. If the neonate is breathing spontaneously, assess whether the neonate has labored breathing and/or cyanosis.
- After the initiation of coordinated ventilation and chest compressions, assess the heart rate only while delivering ventilation. Heart rate assessment after ventilation and chest compressions should be performed without interrupting the ventilation. Even when the heart rate is ≥100 bpm, do not assess the neonate for spontaneous breathing: discontinue chest compressions only and continue ventilation. If the $SpO_2$ level is ≥95%, reduce the oxygen concentration.

# II Assessments in the algorithm

## 1 Breathing

- Breathing is assessed based on its rate and quality. Immediately after birth, neonates must be assessed for quality of breathing, which can be determined by the presence or absence of weak breathing and weak crying. After the initial steps of resuscitation are performed, the presence or absence of spontaneous breathing must be assessed.
- Gasping is an abnormal breathing pattern consisting of rapid inhalation and slow exhalation caused by hypoxia in the brainstem. Both the ventilation cycle and the tidal volume are more irregular during gasping than during normal breathing. Gasping can be regarded as secondary apnea. Distinguishing gasping from normal breathing is difficult, although the heart rate is usually <100 bpm in the case of gasping. Even when the heart rate is ≥100 bpm, it slows down gradually when gasping continues. Thus, when distinguishing between gasping and normal breathing is difficult, it is important to assess both breathing and heart rate every 30 s.
- Labored breathing refers to nasal flaring, grunting, retractions, and tachypnea (≥60/min.).

## 2 Heart rate

- An increase in heart rate is the most reliable indicator of effective resuscitation. For neonates soon after birth, chest auscultation is the first-line approach for assessing heart rate. Although palpation of the arterial pulse is not reliable, the umbilical cord pulsation is better for palpation than other sites. The number of heart beats counted in 6 s is multiplied by 10 to obtain the heart rate in beats per minute.
- Heart rate assessment using a pulse oximeter is superior to auscultation and palpation because it enables objective and continuous assessment. Thus, a pulse oximeter should be used when advancing to the steps involving ventilation and/or respiratory support.
- Facilities that handle many high-risk deliveries are advised to consider the addition of an electrocardiographic (ECG) monitor to obtain more rapid and accurate heart rate measurements. An ECG monitor can show the heart rate more quickly than a pulse oximeter but cannot be used to assess oxygen saturation. Thus, an ECG monitor is not a replacement for a pulse oximeter. Since pulseless electrical activity (PEA) has been reported even in neonates, the initial assessment of heart rate and its assessment after the return of spontaneous circulation via chest compressions must be performed by auscultation.

## 3 Cyanosis (poor oxygen saturation)

- Visual assessment of central cyanosis is not very reliable because results vary among individuals. Furthermore, it is easy to detect cyanosis in polycythemia, but not in anemia; consequently, cyanosis can be missed in anemia, which is characterized by reduced oxygen transport capacity. To solve this problem and use an appropriate amount of oxygen during resuscitation, the use of a pulse oximeter is recommended.
- Peripheral cyanosis, that is, cyanosis of only the tips of the hands and feet, is sometimes observed in healthy neonates for a period after birth and is therefore not an indication for intervention. Oxygen saturation is within the normal range in peripheral cyanosis. On the other hand, central cyanosis, that is, cyanosis of the lips, oral mucosa, and center of the trunk, is a sign of low oxygen saturation and thus indicates that intervention may be required. Central cyanosis is sometimes observed in healthy neonates for several minutes after birth; therefore, the need for interventions must be determined by measuring $SpO_2$ using a pulse oximeter and referring to the target $SpO_2$ at the given time after birth.
- The use of a pulse oximeter is effective for distinguishing between peripheral cyanosis and central cyanosis.

## 4 Gestational age

- Whether a neonate was born at term or preterm is one of the items to assess immediately after birth. The weeks of pregnancy must be confirmed before delivery. If this is unknown because a woman with no prenatal care or emergency delivery outside the health checkup facility, proceed to the initial steps of resuscitation.

## 5 Muscle tone

- The presence or absence of hypotonia is one of the items to assess immediately after birth. Hypotonia is diagnosed when the upper and lower extremities are relaxed and not flexed, and there is little spontaneous movement.

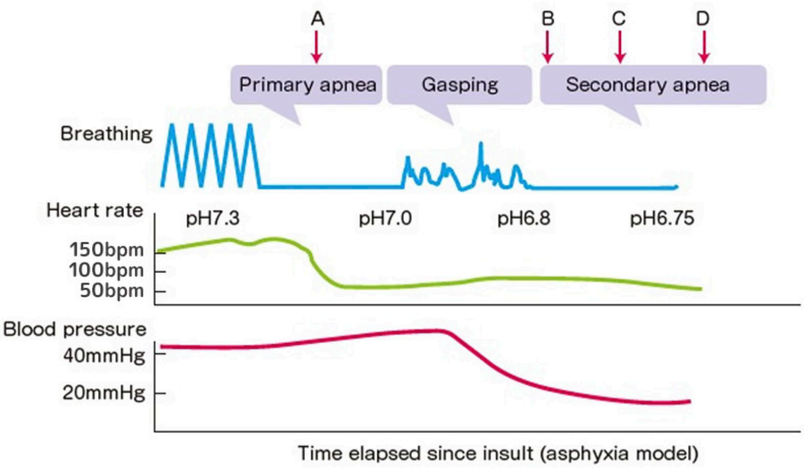
(Shigeharu Hosono)

# III Rationales behind the NCPR algorithm (recognition of primary and secondary apnea)

The NCPR algorithm is a process for determining the severity of exposure to hypoxia that a nonbreathing neonate experienced in utero. The primary of the hypoxic process in utero is based on animal studies conducted in the 1960s.

**Fig. 0-6** shows how the fetus reacts when exposed to hypoxia in utero in an asphyxia model. Specifically, upon exposure to hypoxia, the fetus makes rapid, large chest movements to breathe, but the blood oxygen concentration drops rapidly, and consequently, the fetus loses consciousness within a few minutes. The respiratory cen-

**Fig. 0-6** Primary and secondary apnea (asphyxia model)




(The American Academy of Pediatrics. American Heart Association and John Kattwinkel MD FAAP. et al.: Neonatal Resuscitation Textbook, Fifth Edition. Chapter 1, 2006) ter in the brainstem then becomes dysfunctional due to hypoxia, and the breathing movements stop. This state is called primary apnea. In primary apnea, the heart rate gradually decreases to the level of bradycardia (100 bpm), but the blood pressure remains near the normal level. This is because of the mechanism that prioritizes blood flow to critical organs (i.e., the heart, lungs, and brain) by peripheral vasoconstriction. At the same time, a transition from normal aerobic metabolism to anaerobic metabolism, which consumes less oxygen, takes place. In this way, the fetus manages to maintain circulation while conserving oxygen consumption during primary apnea. However, if primary apnea is prolonged, lactic acid accumulates, gradually leading to acidosis.

When hypoxic status progress further, the fetus will start “gasping”, a special pattern of breathing that is equivalent to agonal breathing in adults. Gasping which is intermittent breathing occurs every once in a 5 s. Circulation is still maintained when gasping starts, but as hypoxia and acidosis progress over time, the gasping stops, which leads to secondary apnea (terminal apnea). Once secondary apnea happens, the intrauterine condition deteriorates rapidly, and myocardial cells gradually stop effectively contracting. At this point, the fetus can no longer maintain adequate circulation, and death will occur if no intervention is implemented.

When a neonate is not spontaneously breathing after birth, you must initiate the initial steps of resuscitation immediately. And you must assess the following status.

Suppose the neonate is born with primary apnea without airway obstruction at the time point indicated by **arrow A in Fig.0-6**. In that case, the neonate starts spontaneous breathing by initiating gentle tactile stimulation because the circulation is sufficiently preserved and the intrauterine environment has not yet deteriorated. If a neonate is born with secondary apnea, at the time point indicated by **arrow B in Fig.0-6**, only tactile stimulation is not enough to start breathing, and ventilation is also required in order to initiate breathing. Because the circulation is still preserved, oxygen taken in via the lungs through ventilation soon reaches the myocardium, and consequently, normal heart beats are reestablished, and oxygenated blood is delivered to the brainstem to establish regular spontaneous breathing.

In advanced secondary apnea, at the time point indicated by **arrow C in Fig.0-6**, the circulation has already deteriorated, and oxygen cannot be delivered to the myocardium. Thus, circulatory support is required, and ventilation with chest compressions must be performed. Note that the purpose of chest compressions here is to push oxygenated blood to the myocardium; therefore, chest compressions are pointless if ventilation is not performed simultaneously.

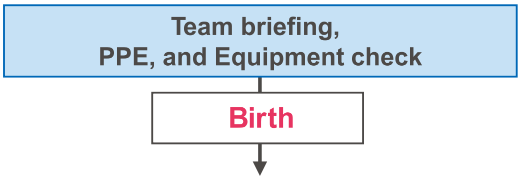
If a neonate is born with more advanced secondary apnea, at the time point indicated by **arrow D in Fig.0-6**, chest compressions alone will be insufficient, and medication (adrenaline) is required to support circulation. If hypoxia has progressed beyond this point, it is too late to save the neonate's life.

It is impossible to determine whether an apneic neonate is in primary or secondary apnea by visual observation alone. An apneic neonate can be diagnosed as primary or secondary apnea with the NCPR algorithm. If a neonate responds to the initial steps immediately and starts breathing, he/she can be determined to have had primary apnea (**Fig. 0-6, arrow A**). A lack of response to the initial steps indicates that the neonate had secondary apnea, and you must ventilate him/her immediately. Immediate resolution of bradycardia indicates early secondary apnea, in which the circulation is preserved (**Fig. 0-6, arrow B**). If bradycardia does not resolve despite the application of appropriate ventilation, the apneic neonate has advanced secondary apnea (**Fig. 0-6, arrow C or D**), and you must provide chest compressions with ventilation.

In summary, using the NCPR algorithm, determine the severity of hypoxia by applying interventions for a short period of time and assessing the neonate's responses to them. In neonatal resuscitation, an apneic neonate is always necessary to be determined with the NCPR algorithm whether he/she has primary or secondary apnea.

(Takahide Yanagi)

# Team briefing




CoSTR2020 suggests the possibility that briefing and debriefing in various clinical settings lead to improvement of the quality of resuscitation and prognosis. Thus, the key to successful neonatal resuscitation is establishing a system in which perinatal risks are assessed in a briefing; staff with adequate knowledge and skills and adequate supplies and equipment to perform resuscitation are allocated accordingly, and the resuscitation that was performed is reviewed in a debriefing. It is desirable that such a system be standardized and used at every facility.

## I Briefing/debriefing

The effects of the following several approaches to briefing/debriefing in neonatal resuscitation have been studied, and the results suggest the that briefing/debriefing improves the short-term clinical outcomes and the practice performed by the staff. Briefing/debriefing approaches include video-assisted debriefing[1)], a combination of a checklist and video-assisted debriefing[2)], team briefing/debriefing using a checklist[3)], and rapid-cycle deliberate practices (rapid cycling between deliberate practice and feedback)[4)].

### Team briefing before providing resuscitation

The first step of preparing for resuscitation is making a concise plan that defines which staff member takes which responsibilities and how the responsibilities are fulfilled. Members of the team must confirm and understand their roles, responsibilities, and expected actions through the briefing. During the briefing, it is important to analyze perinatal risk factors; appoint key persons, such as the main person who will provide resuscitation (team leader) and a record keeper; check necessary materials for resuscitation; and consider whether additional support is needed.



## II Attendance at a cesarean section delivery

It has been reported that compared with normal vaginal delivery, cesarean section delivery under regional anesthesia does not increase the number of term neonates who require endotracheal intubation during resuscitation. Thus, if a term neonate without a known risk is to be delivered by cesarean section under regional anesthesia, attendance by a staff member who can perform ventilation is sufficient.

## III Preparation for resuscitation (including supplies and actions)

It is not always possible to predict the need for resuscitation. Therefore, staff attending even a low-risk delivery must make preparations for resuscitation and have good awareness of when and under which situations additional support needs to be requested. The following are commonly needed supplies and preparatory actions (for details regarding supplies, refer to the section explaining each step):

- Confirm perinatal risk factors;
- Introduce yourself to the mother and other family members;
- Practice hand hygiene and infection control measures (described later);
- Ensure a clean location for performing procedures involving thermal management;
- Check the room temperature and warming equipment (e.g., radiant warmer);
- Ensure the availability of a timer or stopwatch,
- Prewarmed and dried linen (plastic bags/wrap for preterm neonates),
- Ventilation equipment (self-inflating bags, flow-inflating bags, T-piece resuscitators, and face masks),
- An oxygen blender and a gas supply source,
- A stethoscope,
- A pulse oximeter and probe of appropriate size, and
- An EGC monitor and electrodes for neonates (when the need for advanced resuscitation is anticipated);

- Confirm the appropriate size of the suctioning tube and appropriate suctioning pressure; and
- Ensure the availability of equipment for advanced airway management (e.g., endotracheal tubes, a laryngoscope, and a laryngeal mask),
- Equipment to secure venous access (umbilical venous catheters, peripheral venous indwelling needles, and intraosseous needles), and
- Medications (Epinephrine, normal saline, and glycose).

## IV Infection control

Staff who perform resuscitation are at risk of exposure to various infectious diseases, and appropriate preventive measures must be put in place.

Standard preventive measures are basic measures that are implemented irrespective of the mother's and neonate's infection status and disease status to reduce the risk of health care-associated infections in mothers, neonates, and medical professionals. These include practicing hand hygiene (washing and sanitizing hands) and using personal protective equipment (PPE) such as gloves, masks, and gowns (**Fig. 0-1, 0-2**).

**Fig. 0-1**
Standard preventive measures
Put on gloves, a surgical mask, and an apron.

**Fig. 0-2**
Maximal barrier precautions.
Put on gloves, an N95 mask, a gown, goggles, and shoe covers.

To prevent infectious diseases (e.g., COVID-19) that may have a significant impact on the public health, infection control measures must be formulated and implemented in compliance with relevant guidelines and recommendation [5, 6]. Simulations and rehearsals should be performed at each facility to assess whether the order and contents of these proposals are feasible. Additionally, staff members should practice donning and doffing PPE in advance.

Please note that these proposals are based on the limited evidence available as of the time of this publication and may be revised according to new scientific evidence in the future.

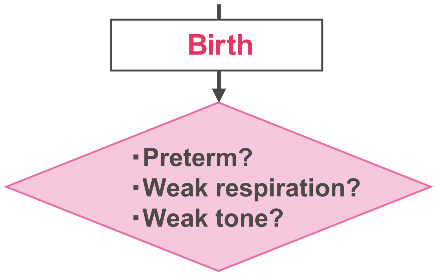
(Takahiro Sugiura)

## Key points

1 The key to successful neonatal resuscitation is establishing a system in which perinatal risks are assessed in a briefing; staff with adequate knowledge and skills and adequate supplies for resuscitation are allocated accordingly, and the resuscitation that was performed is reviewed in a debriefing.

2 Infection control measures must be implemented according to the situation to reduce the risk of health care-associated infections in mothers, neonates, and medical professionals.

# Assess the neonate immediately after birth




To determine the need for resuscitation at birth, a neonate must be assessed for the three criteria shown in **Table. 1-1**: (1) preterm, (2) weak breathing/crying, and (3) weak muscle tone. If at least one criterion is met, the neonate must be transferred to a radiant warmer to initiate resuscitation.

Whether the neonate is preterm or not needs to be assessed because preterm neonates are at higher risk of conditions requiring resuscitation than term neonates with various factors. Preterm neonates will not easily initiate spontaneous breathing because their lungs are stiff, and their respiratory muscles and respiratory centers are poorly developed. Additionally, preterm neonates have more difficulty maintaining body temperature than term neonates do. Thus, even without obvious signs indicating the need to start the initial steps of resuscitation, preterm neonates need careful further assessment while the initial steps are performed in a radiant warmer.

If there is no vigorous crying or breathing accompanied by adequate chest movements, it can be determined that a neonate has weak breathing/crying, and the initial steps of resuscitation must be initiated. As described earlier, gasping is a sign of intrauterine exposure of the fetus to hypoxia, and thus, the initial steps of resuscitation

**Table. 1-1** Criteria checked immediately after birth

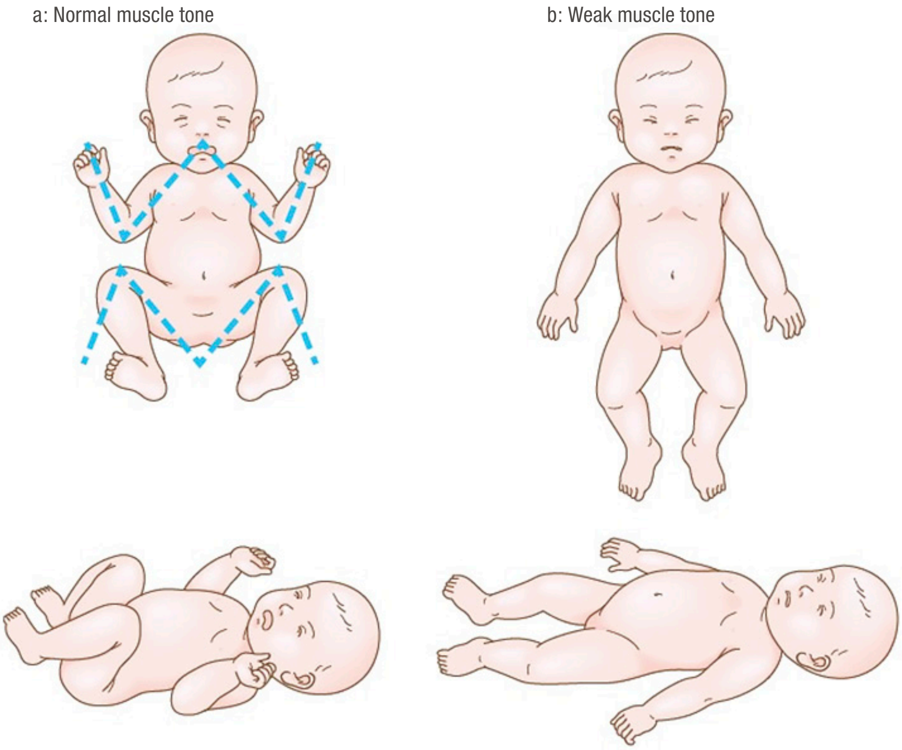
| |
|---|
| 1. Preterm |
| 2. Weak respiration/crying |
| 3. Weak muscle tone |

must be initiated immediately. Gasping should not be mistaken as the presence of spontaneous breathing.

The presence of weak muscle tone is based on whether the neonate flexes his/her extremities while lying down. The extremities of a term neonate with normal muscle tone are in a W-M shaped position. If extremities are floppy and hang straight down, it can be determined that the neonate has weak muscle tone (**Fig. 1-1**).

These three criteria, unlike heart rate and $SpO_2$, can be assessed immediately after birth and judgements can be made instantaneously, allowing resuscitation to be initiated promptly. Additionally, the Apgar score is an objective numerical measure of the neonate's status and is useful for conveying information about the neonate's general condition at birth and responses to resuscitation. However, it cannot be used to determine the need for resuscitation or to decide when resuscitation should take place and which interventions should be performed. The Apgar score is generally examined 1 min and 5 min after birth; this system is too slow to be used to determine the resuscitation strategy. Furthermore, there is no time to spare for calculating the Apgar score during resuscitation.

**Fig. 1-1** Muscle tone in a neonate immediately after birth (extremities in a W-M–shaped position)




（細野茂春（監修）. 病院前新生児蘇生法テキスト. p43, メディカ出版, 大阪, 2020年. より引用）

NCPR2005 also included the examination of meconium-stained amniotic fluid and recommended performing tracheal suctioning if a neonate is born through meconium-stained amniotic fluid and is nonvigorous. However, due to insufficient evidence, this criterion has been excluded since NCPR2010.

If none of three criteria in **Table. 1-1** is met, routine care is provided for the neonate.

(Takahide Yanagi)

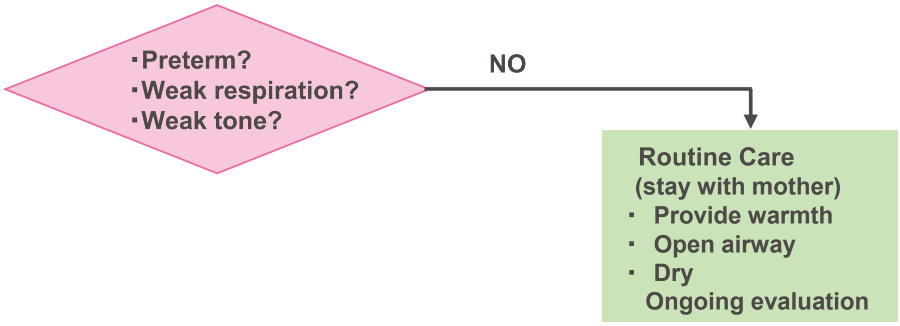
### Key points

**1** To determine the need for resuscitation at birth, a neonate must be assessed for the three criteria: (1) preterm, (2) weak breathing/crying, and (3) weak muscle tone. If at least one criterion is met, the neonate must be transferred to a radiant warmer to start the initial steps of resuscitation.

**2** The Apgar score cannot be used to determine the need for resuscitation or to decide when and which interventions should be used.

# Provide routine care






Routine care is provided for a neonate who does not meet any of the three criteria immediately after birth. More specifically, when a neonate (1) is term, (2) is either crying vigorously or adequate spontaneous breathing, and (3) has good muscle tone, the amniotic fluid must be wiped off to dry the neonate's skin, and the neonate must be placed in a position to open the airway and hypothermia must be prevented using a radiant warmer or similar means. The removal of nasal and oral secretions with gauze or a towel is sufficient, and the oral and nasal suctioning that are routinely performed during delivery and immediately after birth are not required. Aggressive suctioning of the pharynx can cause laryngospasm and bradycardia associated with vagal response, and this can delay the onset of spontaneous breathing.

Labored breathing and cyanosis must be assessed after routine care, and the use of a pulse oximeter must be considered if any problems are observed. Additionally, it is recommended that routine care be performed at the mother's side in consideration of the mother-child relationship. Wiping away amniotic fluid to dry the neonate's skin, placing him/her on the mother's chest, and wrapping them with a bath towel, so that the mother is holding the neonate with direct skin-to-skin contact, is effective for warming the neonate. Early mother-child contact is effective for facilitating bonding, but care providers need to take safety precautions, for example, using a monitor (e.g., a pulse oximeter) and carefully observing the neonate's breathing, body movements, skin color, etc.

(Takenori Kato)

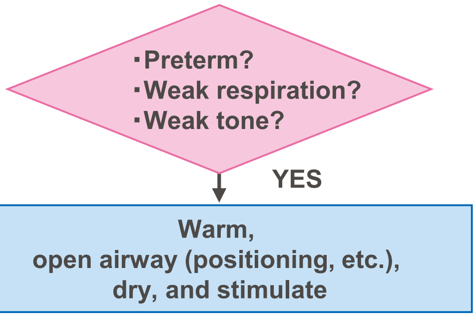
## Key points

1 Routine care (keeping the neonate warm, opening the airway, and drying the skin) is provided for a neonate who does not meet any of the three criteria immediately after birth.

2 It is recommended that routine care be provided at the mother's side in consideration of the mother-child relationship to facilitate bonding, although safety precautions must still be taken.

# Perform initial steps of resuscitation






The initial steps of resuscitation must be initiated for a neonate who meets any of the three criteria (preterm, weak breathing/crying, and weak muscle tone) immediately after birth.

## I Basics of initial steps of resuscitation

Perform the initial steps following the process indicated in **Table. 3-1**

**Table. 3-1** Initial steps of neonatal cardiopulmonary resuscitation

| |
|---|
| 1. Warm and wipe amniotic fluid from skin |
| 2. Perform airways' management (positioning and, if necessary, suctioning to remove meconium or other obstructions) |
| 3. Gently stimulate |
| 4. Reposition for airways' management |

## II Warm and maintain normal temperature

Since NCPR2015, it has been recommended that the core temperature of nonasphyxiated neonates be maintained at 36.5℃-37.5℃ from birth throughout the hospital stay. Additionally, in the algorithm, the importance of maintaining the body temperature is incorporated into all steps of resuscitation, and the body temperature on admission is regarded as a prognostic factor and therefore must be recorded. For preterm neonates born at less than 32 weeks of gestation, it has also been proposed that, in addition to using a radiant warmer, the following measures should be taken on admission to prevent hypothermia (body temperature <36.0℃), while taking care to avoid overheating: appropriate ambient temperature (23℃-25℃), warm blankets, plastic wraps, a cap, and/or a thermal mattress. An ambient temperature ≥26℃ should be considered for neonates born at less than 28 weeks of gestation.

**\ Key point /**

Thermal management must be ensured to maintain the neonate's core temperature at 36.5°C-37.5°C from birth throughout the hospital stay.

**\ Key point /**

For preterm neonates born at less than 32 weeks of gestation, hypothermia must be prevented with the combined use of a radiant warmer with other warming equipment (e.g., plastic wraps), while taking care to avoid overheating.

## III Airway management (positioning and suctioning as needed)

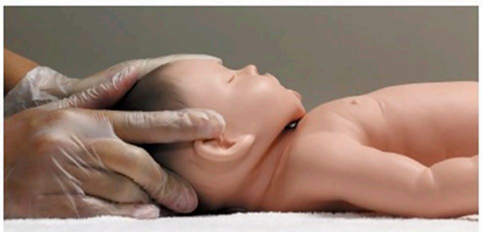
If the need for the initial steps of resuscitation is confirmed, the neonate must be promptly positioned in the supine "sniffing position" (in which the neck is slightly extended, the head is tilted backward, and the chin is lifted) for airway management. For a neonate whose occiput is large, the placement of a shoulder roll (a rolled-up hand towel) under the shoulders helps keep the neonate in position for airway management [7] (**Fig. 3-1**).

**Fig. 3-1** Shoulder roll for airways' management

**a** : Position for airways' management using a shoulder roll (correct position)

**b** : Airways' obstruction due to excessive backward bending of the head (incorrect position)

**c** : Airways' obstruction due to large head size (incorrect position)



Weak breathing or inadequate ventilation despite the presence of labored breathing indicates airway obstruction that required suctioning. In this case, oral suctioning must be performed first using either a rubber bulb syringe or a suctioning catheter with the suction pressure <100 mmHg (13 kPa)[8], and then nasal suctioning must be performed (**Fig. 3-2**). This is because nasal suctioning tends to induce spontaneous breathing, and performing nasal suctioning before oral suctioning increases the risk of aspiration of oral secretions.

The size of the suction catheter depends on whether the amniotic fluid is stained with meconium. If the amniotic fluid is meconium-stained, a large-bore suction catheter (12 or 14 Fr) should be used for oral and nasal suctioning. If the amniotic fluid is clear, a 6-Fr or an 8-Fr catheter must be used for low birthweight neonates, depending on their weight, and a 10-Fr catheter should be used for term neonates (**Fig. 3-3**). Stimulation of the pharynx within several minutes after birth may induce a vagal response that can cause bradycardia and apnea; therefore, deep insertion of the catheter into the pharynx and prolonged implementation of the suctioning procedure must be avoided.

Suctioning of the oral and nasal cavities must be completed within

**Fig. 3-2** Suctioning with a suction bulb syringe (the mouth first and then the nose)

If the neonate is not breathing spontaneously, suction the oral cavity first and then the nasal cavity.

**a** : Oral suctioning **b** : Nasal suctioning

**Fig. 3-3** Suctioning with a suction catheter (suction the mouth first and then the nose)

If the neonate is not breathing spontaneously, suction the oral cavity first and then the nasal cavity.

**a** : Oral suctioning **b** : Nasal suctioning (do not insert too deep)

approximately 5 s, and caution should be taken to avoid aggressive or deep suctioning.

Routine suctioning is not necessary if the amount of secretions is small and breathing is normal. In NCPR2005, if the amniotic fluid is meconium-stained, the removal of any meconium that is present in the airway was prioritized over the induction of spontaneous breathing to prevent meconium aspiration syndrome. However, in NCPR2010 and NCPR2015, it is recommended that routine suctioning is not necessary, even for nonvigorous neonates born through meconium-stained amniotic fluid, because of the inadequate evidence that the onset of meconium aspiration syndrome and mortality is reduced when tracheal suctioning is performed compared with when it is not performed [9, 10]. Since 2015, three new randomized controlled studies [11-13] and one observational study [14] have been reported, and a meta-analysis of these studies did not show the efficacy of routine tracheal suctioning [15]. Thus, in NCPR2020, greater emphasis is placed on "not performing tracheal suctioning routinely". Nevertheless, it is not contraindicated, and therefore, an appropriate suctioning method can be chosen (e.g., if a care provider is proficient in endotracheal intubation, intubation and suctioning may be performed).

However, if the neonate is vigorous even with meconium staining of the amniotic fluid, tracheal suctioning will not improve the prognosis and can cause complications of suctioning and intubation [16]. Thus, tracheal suctioning is not recommended for such neonates, unlike in the past.

Furthermore, suctioning during delivery does not prevent meconium aspiration syndrome when the amniotic fluid is meconium-stained [17]. Moreover, oral and nasal suctioning has been found to potentially cause respiratory and circulatory complications [18, 19]. Therefore, routine oral and nasal suctioning during delivery is not recommended, regardless of whether the amniotic fluid is meconium-stained.

**Key point**

Placing a shoulder roll under the shoulders facilitates the positioning of the neonate for airway management.

**Key point**

When performing tracheal suctioning in a neonate who is not breathing spontaneously, oral suctioning must be performed first, followed by nasal suctioning.

**Key points**

The appropriate size of the suction catheter is as follows:

- When the amniotic fluid is meconium stained: 12 or 14 Fr
- Term neonates: 10 Fr
- Low birth weight neonates: 6 or 8 Fr

**Key point**

Suctioning pressure must not exceed 100 mmHg (13 kPa).

## IV Tactile stimulation

The first breath is induced by tactile stimulation. Wiping off the skin with a dry towel not only prevents hypothermia but also induces breathing.

Warmed, absorbent towels should be made available in advance in preparation for resuscitation. Place one of these towels under the neonate after birth and use it to wipe moisture from the surface of the body. After that, remove the first towel and use another warmed

**Key point**

Stimulate the skin gently, and do not take any longer than necessary for the induction of spontaneous breathing.

**Fig. 3-4** Tactile stimulation to induce breathing

If the neonate is not breathing spontaneously, stimulate the soles of the feet or the back to induce breathing.

**a**: Stimulation of the soles of the feet

**b**: Stimulation of the back

towel to gently rub the neonate's back, trunk, or limbs.

If this does not induce spontaneous breathing, tap the soles of the neonate's feet with the palm of the hand or flick them with the fingertips two or three times (**Fig. 3-4a**). Gently rubbing the back is another acceptable approach (**Fig. 3-4b**). After this, re-position the neonate for airway management.

## V Time used for initial steps of resuscitation

The time frame of within 60 s for initiating ventilation has been indicated since NCPR2015. This does not mean that the initial steps must be performed until 60 s after birth; rather, it means that ventilation must be started by 60 s after birth at the latest.

In the NCPR2010 algorithm, breathing and heart rate are assessed 30 s after the initial steps of resuscitation are performed, before proceeding to the next step. Maintaining this 30-s time frame is effective for inexperienced care providers to prevent a life-threatening delay in initiating resuscitation, but there is little scientific evidence to support it, and the early introduction of ventilation has been reported to be effective in neonates who have responded poorly to initial steps of resuscitation. Consequently, this point is debatable.

In light of the above findings, the detail of "30 s" after birth has been removed as of NCPR2015. This change occurred to ensure that care providers avoid delays in resuscitation by performing the initial steps of resuscitation within approximately 30 s and then assessing breathing and heart rate while remaining prepared to promptly initiate ventilation when the need is confirmed, even if the initial steps of resuscitation have not been performed for 30 s.

(Takenori Kato)

**Key points**

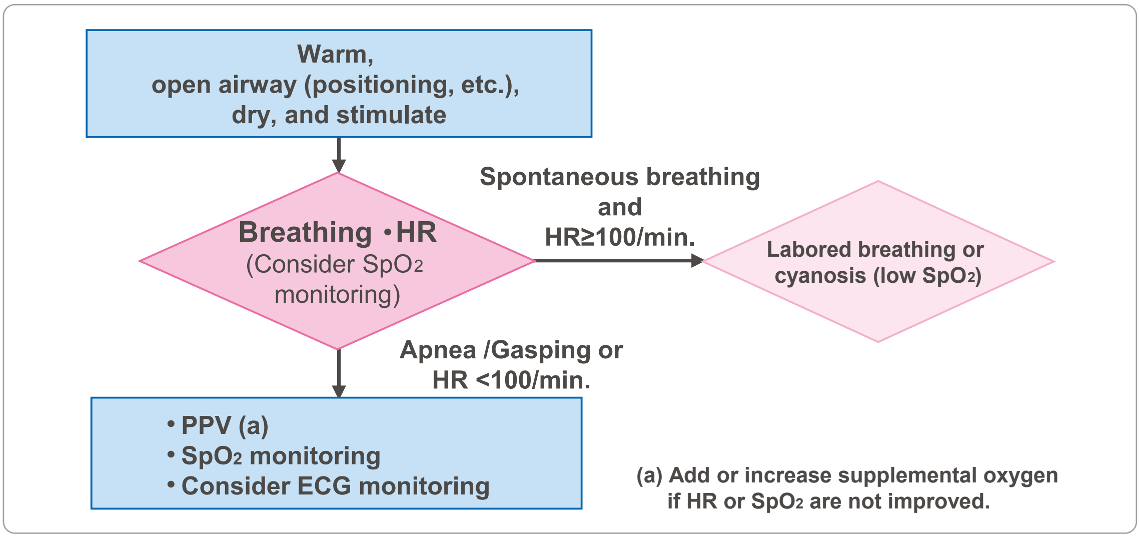
- The rule of thumb is to perform the initial steps of resuscitation for 30 s, but shortening this time for the early introduction of ventilation must be considered according to the circumstances.
- Ventilation must be initiated no later than 60 s after birth upon the confirmation of the need for ventilation.

## Key points

1. The initial steps of resuscitation must be initiated for a neonate who meets any of the three criteria (preterm, weak breathing/crying, and weak muscle tone) immediately after birth.
2. It is recommended that the body temperature of nonasphyxiated neonates be maintained at 36.5℃-37.5℃ from birth throughout the hospital stay. For preterm neonates born at less than 32 weeks of gestation, hypothermia (body temperature <36.0℃) must be prevented. An ambient temperature ≥26℃ should be considered for neonates born at less than 28 weeks.
3. If signs of asphyxia are observed, the neonate must be positioned in the supine "sniffing position" for airway management. Weak breathing or inadequate ventilation despite the presence of labored breathing indicates airway obstruction that required suctioning.
4. Wiping off the neonate's skin with a dry towel prevents hypothermia and provides tactile stimulation to induce breathing.
5. Time to spend on the initial steps of resuscitation: Ventilation must be started by 60 s after birth at the latest.

# Assess effectiveness of initial steps






## I Check breathing and heart rate

After the initial steps of resuscitation (1. warm and maintain normal temperature, 2. Open the airway, and 3. dry the skin and provide tactile stimulation) are performed, check breathing and heart rate to assess the effectiveness of the initial steps. When resuscitation and/or respiratory support is required, attach a pulse oximeter to the right wrist or palm of the neonate. Facilities that handle many high-risk deliveries are advised to consider the addition of an ECG monitor to achieve more rapid and accurate heart rate measurements.

### 1 Breathing

Assess whether the neonate is breathing and crying vigorously. Gasping is not effective breathing and must be regarded as apnea.

### 2 Heart rate

A prompt increase in heart rate is the most reliable indicator of the effectiveness of resuscitation [20]. Palpation of the umbilical pulse, which was recommended previously, is superior to palpation of other parts of the body, but the heart rate is likely to be underestimated, and therefore, direct auscultation of the chest is a more reliable method [21, 22]. The number of heart beats counted in 6 s is multiplied by 10 to obtain the heart rate per minute. A pulse oximeter and an ECG monitor (see below) can provide a more objective and continuous assessment of heart rate.

## II Pulse oximeter (Fig. 4-1)

Since NCPR2010, the use of a pulse oximeter in delivery rooms has been recommended. The use of a neonatal probe and a pulse oximeter designed to reduce artifacts produced by body movements enables the measurement of $SpO_2$ and heart rate within 90 s after attachment [23, 24], but in the actual setting, providers find that measurement takes longer. The preductal value obtained at the right wrist or palm is higher than the post-ductal value obtained at the left hand or left leg [25, 26], and the reference range for $SpO_2$ measured at the right wrist or palm has been reported [27]. When resuscitation and/or ventilation are required, the probe of a pulse oximeter should be attached to the right hand, where free from the interference of the ductus arteriosus.

**Fig. 4-1** Pulse oximeter

a: Pulse oximeter


b: Probe for neonates


(マシモジャパン株式会社より画像提供)

## III ECG monitor

Facilities that handle many high-risk deliveries, especially general and regional perinatal medical centers, are advised to consider use of an ECG monitor to achieve more rapid and accurate heart rate measurements (see p. 83, STEP 5 II, Attachment of an ECG monitor).

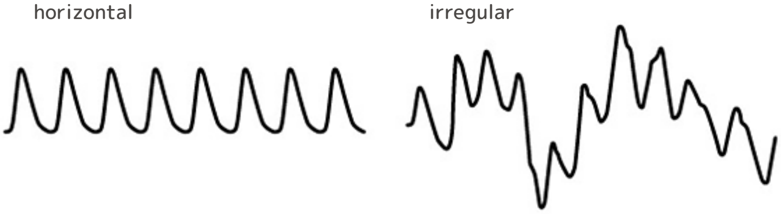
## IV Practical assessment of the heart rate

If a pulse oximeter is already attached, and consistent waveforms are observed, consider the displayed heat rate as the neonate's heart rate (**Fig. 4-2**). If an ECG monitor is already attached and ECG waveforms are detected, use those to obtain the heart rate. However, for neonates in a serious condition, differential diagnosis of PEA is required; therefore, auscultation needs to be performed during the first heart rate assessment and the reassessment after chest compressions are performed.

**Fig. 4-2** Pulse oximeter waveforms

**a**: Good waveforms
Pulse amplitude and width are consistent, and the baseline is horizontal

**b**: Poor waveforms
Pulse amplitude and width are irregular, and the baseline is irregular



# V Branching point to either resuscitation or stabilization

If apnea, gasping, or bradycardia (heart rate 100 bpm) is confirmed through the assessment of breathing and heart rate, initiate bag-mask ventilation immediately, and attach a pulse oximeter to the neonate's right hand (rescue sequence).

On the other hand, if labored breathing (nasal flaring, nasal grunting, retractions, and tachypnea) or central cyanosis is confirmed, attach a pulse oximeter to the neonate's right hand, and then choose either watchful waiting or treatment such as CPAP or oxygen administration (stabilization sequence). More precisely, if central cyanosis is confirmed, urgent oxygen administration is not necessary, but the neonate must be observed carefully with reference to the changes in $SpO_2$ in normal term neonates, which were described earlier (see p. 72, STEP 5, Fig. 5-1, Changes in neonatal $SpO_2$), to determine the timing of oxygen administration. If both labored breathing and central cyanosis are observed, a conventional approach (CPAP or free-flow oxygen delivery) must be taken. If only labored breathing is observed, consider providing CPAP and observe breathing carefully (see p. 100, STEP 8, Stabilization of breathing).

(Takahiro Sugiura)

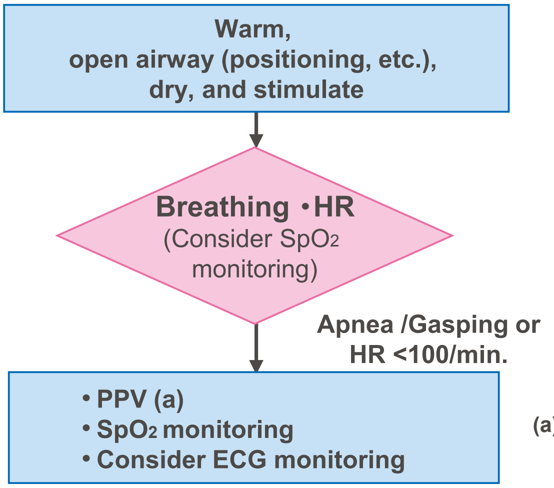
## Key points

1 After the initial steps of resuscitation, assess two measures (breathing and heart rate).

2 Assess heart rate by auscultation first. Use a pulse oximeter, and consider the use of an ECG monitor for more rapid and accurate heart rate measurements.

# Provide ventilation






**Target $SpO_2$**

| Time | $SpO_2$ (%) |
|---|---|
| 1min. | ≥60 |
| 3min. | ≥70 |
| 5min. | ≥80 |
| 10min. | ≥90 |

(a) Add or increase supplemental oxygen if HR or $SpO_2$ are not improved.

## I Ventilation

### 1 Initiating Ventilation

**(1) Following the initial steps of resuscitation, initiate ventilation upon noting apnea,gasping, or bradycardia (heart rate <100 bpm).**

In the rescue sequence of the algorithm, it is important to initiate effective ventilation within 60 seconds after birth. Over 90% of asphyxiated neonates can be resuscitated without additional intervention beyond bag-mask ventilation, soventilation should be mastered both in theory and in practice.

**Key point**

A rapid increase in heart rate is the most reliable indicator of the effectiveness of resuscitation.

**(2) In the stabilization sequence, if breathing does not improve despite the provision of CPAP or oxygen administration**

If both labored breathing and poor oxygen saturation persist despite the provision of CPAP or oxygen administration, consider initiating ventilation while searching for the cause (for details, see p.100, STEP 8, Stabilization of breathing).

## 2 Administering oxygen and target $SpO_2$ values

Initiate ventilation with room air for term neonates and preterm neonates born at ≥35 weeks of gestation. If ventilation is required, be sure to attach a pulse oximeter to the neonate's right hand, which is not affected by the ductus arteriosus. It may take several minutes for the pulse oximeter to produce measurement results after being attached. Thus, until accurate $SpO_2$ values are displayed, observe the neonate carefully for central cyanosis by inspecting the color of the lips, tongue, and skin of the trunk. If the heart rate does not increase or oxygenation does not improve (no alleviation of cyanosis or no improvement in the $SpO_2$ value) despite the provision of effective ventilation, consider administering oxygen.

In NCPR2020, the stabilization sequence was changed to recommend providing CPAP or oxygen administration, if required, after attaching a pulse oximeter to the neonate when either labored breathing or central cyanosis (poor oxygen saturation) is observed. In the clinical setting, determine the timing of oxygen administration based on the previously published changes in the $SpO_2$ value in normal term neonates [28] (**Fig. 5-1**) and the neonate's breathing. The target $SpO_2$ for both term and preterm neonates is ≥60% at 1 min after birth, ≥70% at 3 min after birth, ≥80% at 5 min after birth, and ≥90% at 10 min after birth, with an upper limit of 95% during oxygen administration.

Use a mixture of oxygen and room air prepared with an oxygen blender. Start with an oxygen concentration of approximately 30% and adjust the concentration while assessing heart rate, skin color,

**Key point**

Initiate ventilation with room air in term infants.

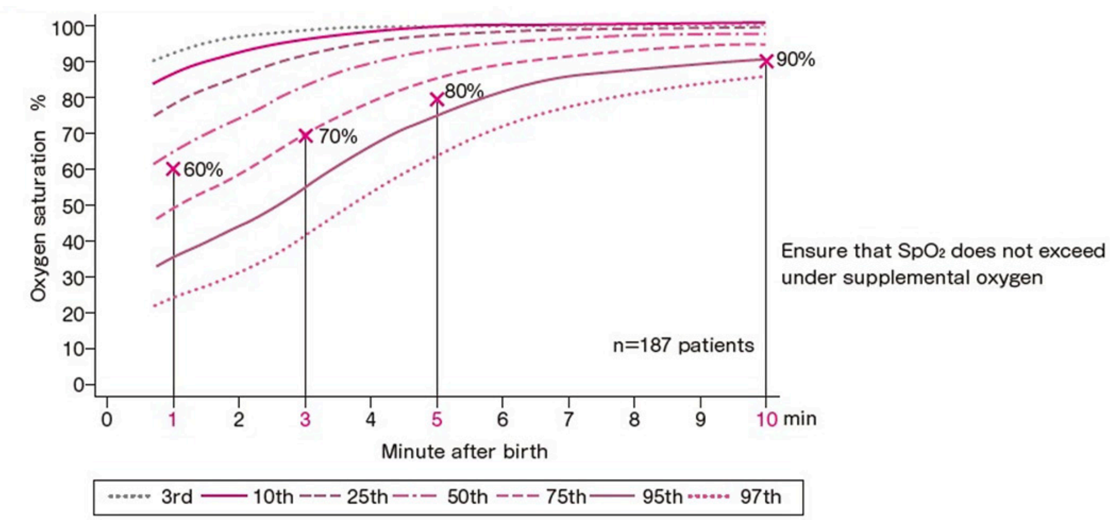
**Key point**

In the stabilization sequence, if either labored breathing or central cyanosis is observed, attach an $SpO_2$ monitor, and if necessary (in the absence of a tendency toward improvement), provide CPAP or administer oxygen.

**Key point**

Cyanosis is a condition that develops when the concentration of deoxygenated hemoglobin in capillaries exceeds 5 g/dL. Neonates with polycythemia are prone to cyanosis.

**Fig. 5-1** Changes in neonatal $SpO_2$




(Adapted from Jennifer A. Dawson et al.: Defining the Reference Range for Oxygen Saturation for Infants After Birth. Pediatrics. Published online May 3, 2010; DOI: 10.1542/peds.2009-1510) and $SpO_2$ value (**Fig. 5-2a**). During oxygen administration, when the $SpO_2$value reaches 95% or higher or exceeds the target value, despite not reaching 95%, and shows a increasing trend, consider reducing or terminating oxygen administration. On the other hand, if the heart rate remains under 100 bpm or the oxygenation status does not improve after oxygen administration is initiated, consider increasing the oxygen administration to normalize the heart rate and improve oxygenation status.

When a blender is unavailable, attach an oxygen tube to a self-inflating bag without a reservoir and use them for ventilation. If the $SpO_2$ value does not reach the target value, attach a reservoir to administer a higher concentration of oxygen (for details, see the section on self-inflating bags).

Although there are no clearly defined standards for the oxygen concentration at which to start chest compressions, increase the oxygen concentration to 80%-100% according to the heart rate, skin color, and $SpO_2$ value.

### Resuscitation of preterm neonates (<35 weeks of gestation)

As in NCPR2015, in NCPR2020, the initiation of ventilation using a low oxygen concentration (21%-30%) is also recommended when resuscitating preterm neonates born earlier than 35 weeks of gestation to avoid excessive exposure to oxygen (NLS864). As in the procedure for term neonates, attach a pulse oximeter to the neonate, and adjust the oxygen dose to achieve the target $SpO_2$ (≥60% at 1 min after birth, ≥70% at 3 min after birth, ≥80% at 5 min after birth, and ≥90% at 10 min after birth, with an upper limit of 95%).

## 3 Supplies required for ventilation

A set of supplies required for ventilation is shown in **Fig. 5-2b**. Supplies must be inspected routinely for shortages, damage, and dead batteries.

Either of two types of bags (a self-inflating bag or a flow-inflating bag) or a T-piece resuscitator can be used for ventilation. Ideally, care providers should be able to use any of these, but they should at least be trained to confidently deliver ventilation using familiar supplies.

**Key point**

If the heart rate does not increase or oxygenation does not improve to an acceptable level (i.e., if there is no alleviation of cyanosis or no improvement in $SpO_2$ value) despite the provision of effective ventilation, consider oxygen administration. In this situation, start with an oxygen concentration of approximately 30%, and adjust the concentration as needed.

**Key point**

Both hyperoxemia and hypoxemia must be avoided during neonatal resuscitation.

**Key point**

Initiate ventilation with low oxygen (21 to 30%) in preterm infants.

## Fig. 5-2 Set of supplies required for ventilation

a: Oxygen flowmeter and blender

b:
① (Optional) Laryngeal mask (LM) (Size 1)
② Face mask
③ Flow-inflating bag (with manometer)
④ Self-inflating bag (with closed-system oxygen reservoir)
⑤ Endotracheal tubes (with internal diameters of 2.5,3, and 3.5 mm) and stylet
⑥ End-tidal $CO_2$ monitor
⑦ Feeding tube
⑧ Laryngoscope (straight blade) (No. 0 and 00 blades)
⑨ Stethoscope
⑩ Suction catheters (6, 8, 10Fr) and suction bulb syringe (12,14Fr will be prepared as needed)

## 4 Self-inflating bag (Fig. 5-3a-c)

One advantage of a self-inflating bag is that it enables the prompt initiation of ventilation because it does not require a gas supply. It also has an overpressure protection valve (pressure release valve). Disadvantages are that it cannot be used to administer free-flow oxygen without attaching a special closed-system oxygen reservoir and that the mask can be pressurized even when not sealed tightly to the face, making it difficult to determine whether proper ventilation is being provided. If a blender is not available, a self-inflating bag without a reservoir can be attached to the oxygen tube to adjust the oxygen concentration to a certain degree. In practice, the oxygen concentration to be administered will vary depending on factors such as the manufacturer of the bag, the ventilation rate, ventilation pressure, and oxygen flow rate (in L/min) (**Fig. 5-4**).[29] Attaching a reservoir allows for administration of high oxygen.

**Key point**

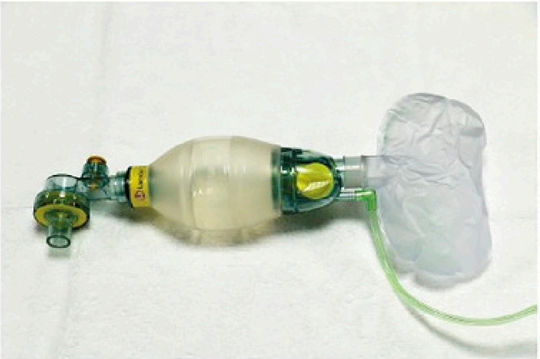
A special reservoir is needed for administration of freeflow oxygen with a self-inflating bag.



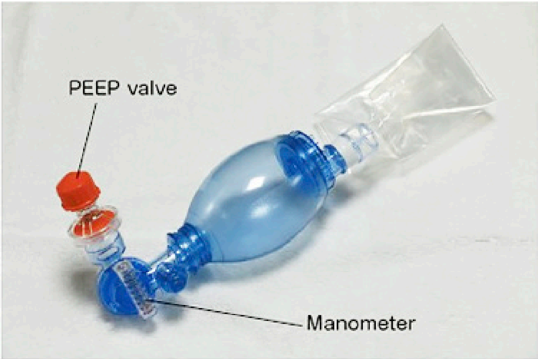


**Fig. 5-3** Self-inflating bag

a: Self-inflating bag with closed-system oxygen reservoir (enables administration of high oxygen)

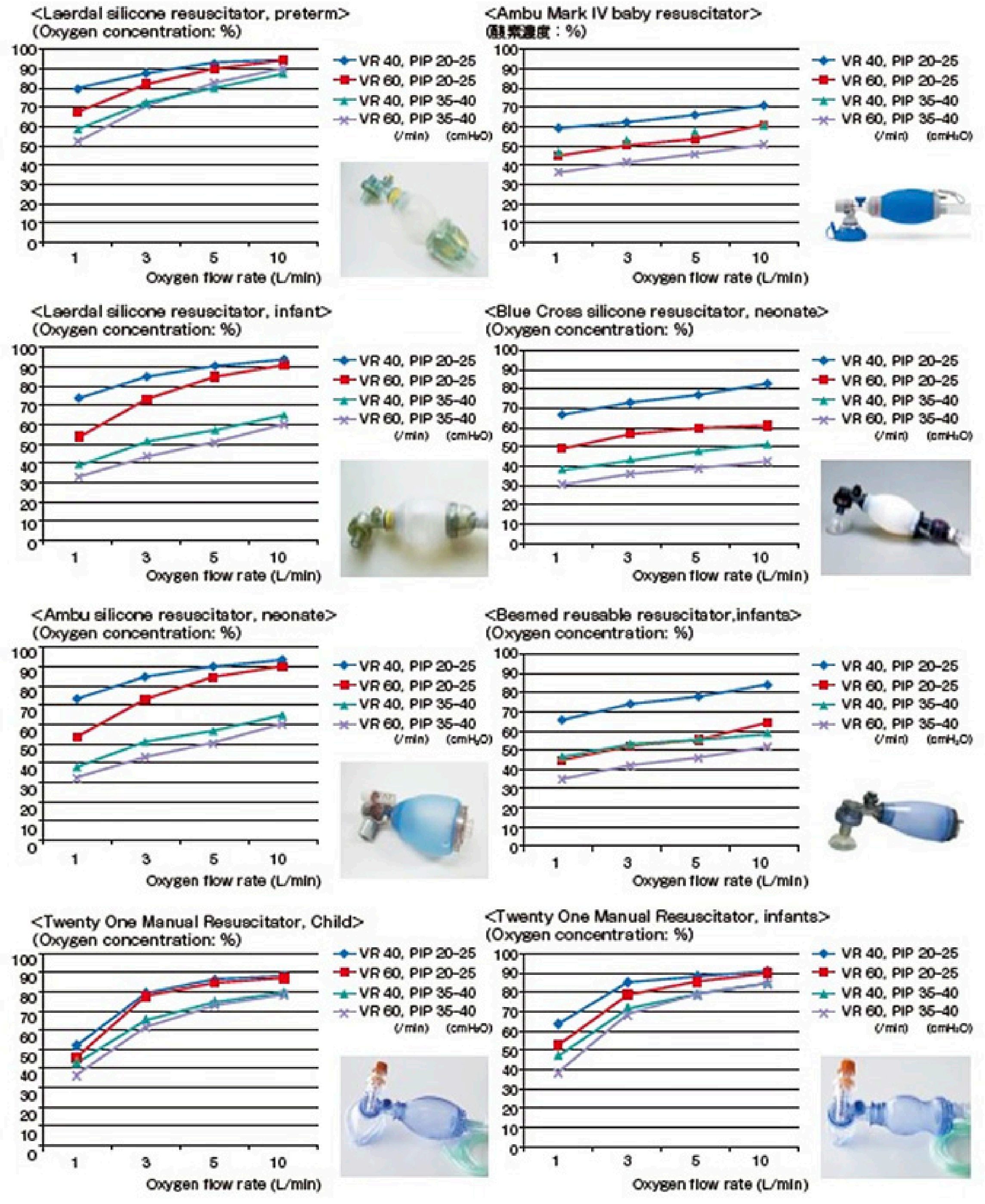


b: Self-inflating bag with closed-system oxygen reservoir equipped with Positive end expiratory pressure (PEEP) valve and manometer




c: Pre-use inspection of self-inflating bag (confirm that pressure release valve is functioning properly)

**Fig. 5-4** Self-inflating bags and range of oxygen concentrations without reservoir




(Based on Takahiro S, et al : Oxygen delivery using neonatal self-inflating bags without reservoirs. Pediatrics International 59 : 154-158, 2016 doi : 10.1111/ped.13184)

The ideal bag volume is 450-500 mL (for neonates weighing ≤5 kg, the target tidal volume is 4-8 mL/kg); a bag that enables the application of a peak inspiratory pressure ≥30 $cmH_2O$ must be selected. The pressure release valve should be triggered at ≤45 $cmH_2O$, and, if necessary, ventilation at higher pressure should be able to be delivered by adjusting the valve [30]. Self-inflatable bags enable ventilation in a disaster medicine setting when the gas supply is interrupted, and it is therefore recommended to keep them ready for resuscitation during a disaster.

**Key point**

Self-inflatable bags enable ventilation when the gas cylinder becomes empty during delivery or when the gas supply is interrupted during a disaster.

## 5 Flow-inflating bag (Fig. 5-5)

A flow-inflating bag requires a gas supply. A flow rate of approximately 5 to 10mL/min is optimal for neonatal resuscitation. Using the gas supply, oxygen can be administered at the exact concentration, which enables the administration of either high or free-flow oxygen. Flow-inflating bags have the following advantages: they can

also be used for mask CPAP with room air, and it is easy to determine if the mask is airtight because the bag will not inflate if the mask is not tightly sealed. Experts can also feel lung compliance by touching the bag as it inflates.

However, when using a flow-inflating bag without a pressure release valve, it is essential to attach a manometer (pressure gauge) to check ventilation pressure. Additionally, the use of a flow-inflating bag when a blender is not available means that ventilation and CPAP are performed with 100% oxygen, and thus, caution must be exercised to avoid hyperoxemia in the neonate.

**Key point**

When using a flow-inflating bag, connect a manometer to the bag to monitor ventilation pressure.

### Inspection of bag before use

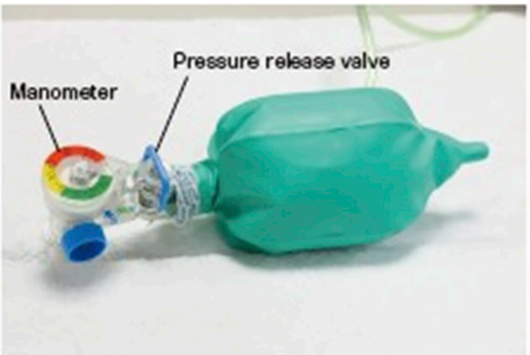
As shown in **Figure 5-5b**, place a hand over the mask to apply pressure to the bag and check whether the bag inflates properly, whether pressure increases sufficiently, whether there are any leaks, and whether the manometer is working.

**Key point**

When using a flow-inflating bag, it is ideal to use a blender and attach a pulse oximeter to the neonate to prevent hyperoxemia.

**Fig. 5-5** Flow-inflating bag

a: With manometer and pressure release valve




b: Pre-use inspection

## 6 T-piece resuscitator (Fig. 5-6)

Along with self-inflating bags and flow-inflating bags, the T-piece resuscitator is another ventilation device, and its use is spreading gradually throughout Japan. It is easy to operate and enables positive end-expiratory pressure (PEEP) to be set when providing CPAP or intermittent positive pressure ventilation (IPPV). However, there is no evidence for or against the superiority of a T-piece resuscitator versus bag ventilation, and therefore, any of these devices can be used for neonatal resuscitation (NLS870).

A T-piece resuscitator enables a preset peak inspiratory pressure (PIP) to be applied by covering the expiratory valve (PEEP/PIP switching hole), which is located near the connection to the mask, with a finger. The inspiratory time is the time when the expiratory valve is covered with a finger. PEEP is provided upon the removal of the finger from the expiratory valve (**Fig. 5-7**).

**Fig. 5-6** T-plece resuscitator

a: Preset peak inspiratory pressure (PIP) and positive end-expiratory pressure (PEEP) can be applied by connecting the resuscitator to a gas supply. It There is some resemblance resembles to a flow-inflating bag but this device offers easier and safer pressure adjustment.


b: Releasing the expiratory valve produces expiration (PEEP)

c: Occluding the expiratory valve produces inspiration (PIP)

PEEP is adjustable by pulling the PEEP knob up and turning it clockwise or counterclockwise. Air leakage and pulmonary injury due to excessive pressure can be avoided by setting the maximum opening pressure on the main unit and monitoring the circuit pressure while performing resuscitation. The disadvantages of a T-piece resuscitator are that it requires a gas supply and is ineffective if there is substantial leakage due to poor mask placement and that users cannot feel lung compliance.



## 7 Choosing a mask

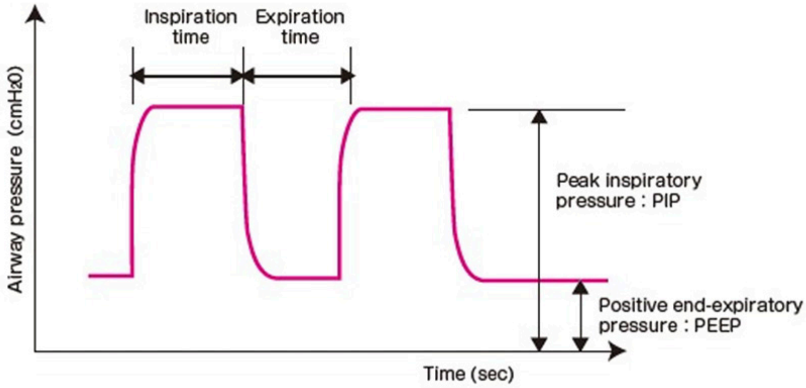
There are two types of masks: round and anatomic (**Fig. 5-8**). Choose a mask size that will cover the neonate's nose and mouth but not the eyes (**Fig. 5-9**) because pressure on the eyes can lead to eye damage or bradycardia associated with vagal response. A mask with a cushion can seal the face easier and will not leak much from the edges.

**Key point**

- Choose a mask size that will cover the nose and mouth but not the eyes
- Pressure on the eyes can lead to bradycardia associated with vagal response must adjust the oxygen concentration.

**Fig. 5-7** Ventilation with a T-plece resuscitator

Peak inspiratory pressure (PIP) and positive end-expiratory pressure (PEEP)




T-piece resuscitator allows for accurate setting of PIP and PEEP. Inspiration time can also be freely adjusted by changing the duration (the valve is occluded with a finger).

**Fig. 5-8** Mask shapes

An anatomical mask is easier to seal tightly to the face than a circular mask.

a: Round mask

b: Anatomic mask

## 8 Providing bag-mask ventilation

When providing ventilation, hold the neonate's jaw and seal the mask with one hand while squeezing the bag with the other. Make a" C" with the thumb and index finger to seal the mask tightly to the face. Use the middle finger ("I" shape) to gently lift the jaw (**Fig. 5-10**). This is called the IC clamp technique. The airway can be easily opened for ventilation by putting the neonate in the" sniffing position" with the neck slightly extended, the head bent backwards, and the jaw lifted. Placing a rolled towel or small blanket under the shoulders facilitates opening the airways without

consciously lifting the jaw, enabling complete focus on keeping the mask sealed to the face (**Fig. 5-11**).

The pressure used for initiating ventilation with room air immediately after birth is usually 30 $cmH_2O$ for term infants and 20 to 25 $cmH_2O$ for preterm infants. However, a higher pressure (~40$cmH_2O$) or longer inspiration time may be

necessary in some cases. The neonate's chest movements are a more reliable indicator for assessing the effectiveness of ventilation. If pressure is not being monitored, ventilation should be provided using the minimum amount of pressure required to increase heart rate, and

**Key point**

- Placing a shoulder roll under the shoulders facilitates airway opening.
- The positions for ventilation and intubation are not the same. Removing the shoulder roll and placing padding under the head helps maintain the sight into glottis once the laryngoscope has been inserted

**Fig. 5-9** Face mask

**a**: Incorrect (too large) **b**: Correct (appropriate size)

**Fig. 5-10** IC clamp technique

excessive chest wall movements should be avoided.

Ventilation must be delivered at a rate of 40 to 60 breaths per minute (30 breaths per minute when combined with chest compressions). No matter how critical the situation, ensure that the ventilation rate does not exceed one breath per second.

**Key point**

- No matter how critical the situation, be sure to avoid excessive ventilation of more than one breath per second (60 per minute) !



## (1) Sustained inflation

Sustained inflation at birth was a PICO question that was also discussed in NCPR2020. This is still not a common procedure in Japan, and there is insufficient evidence to recommend it. Thus, it is proposed that sustained inflation (≥5 s) not be routinely used for transitioning preterm neonates who have bradycardia or are not breathing spontaneously.

## (2) When prolonged ventilation is required

When providing ventilation for more than several minutes, insert a 6–10 Fr feeding catheter into the stomach via the mouth, and suction the air and stomach contents thoroughly. Then, provide ventilation with the end of the catheter left open (**Fig. 5-12**). This prevents poor extension of the lungs and reflux and aspiration of stomach contents due to distension of the stomach. However, care must be taken to avoid leakage from the mask due to the presence of the catheter.

**Fig. 5-11** Bag-mask ventilation technique

### (3) When bag-mask ventilation is not feasible

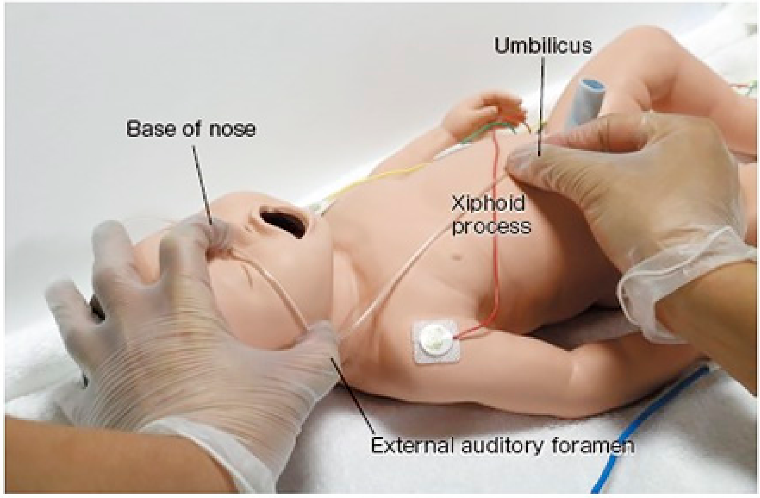
When a delivery occurs at a location that is not properly equipped (e.g., in a car or at home), resuscitation needs to be performed without devices. In such situations, mouth-to-mouth-and-nose resuscitation is performed.

To perform this procedure, open the airway using the head-tilt, chin-lift maneuver; cover the neonate's mouth and nose with your mouth through a face shield; and give the first rescue breath for 1 to 1.5 s while observing the neonate's chest movements (**Fig. 5-13**). Mouth-to-mouth-and-nose resuscitation without anti-infection appliances (e.g., a face shield) is not recommended because of the risk of infection.

(Hiroyuki Kitano)

**Fig. 5-12** Measuring the length of the tube to place in the stomach

Base of nose - External auditory foramen
- Midpoint of xiphoid process and umbilicus



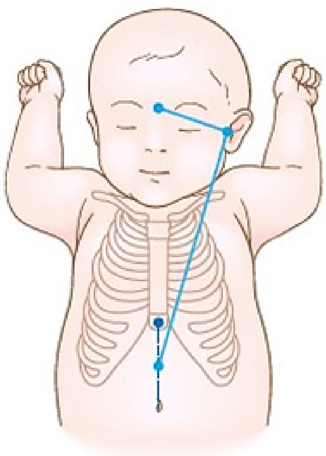



**Fig. 5-13** Mouth to mouth and nose rescue breathing

# II Use of ECG monitor

Acquiring accurate heart rate information is crucial for judging the need for neonatal resuscitation and its success. When bradycardia persists, the need for a better or more advanced intervention must be considered. Auscultation alone may not allow proper assessment of the heart rate, leading to the selection of inappropriate actions [31]. Furthermore, a pulse oximeter requires several minutes to produce measurements and may also show low heart rates for several minutes immediately after birth [32].

Several observational studies have demonstrated that ECG monitors are more useful than pulse oximeters for rapidly and accurately measuring heart rate [33-35], and therefore, they are expected to be disseminated to and used in facilities, particularly those that handle a large number of high-risk deliveries.

An ECG monitor can be used during the ventilation steps when a neonate requires resuscitation.

## 3 ECG with leads [34] (Fig. 5-14)

When the body surface is wet or coated by vernix caseosa, it is difficult to attach electrodes, and a long time is required until waveforms stabilize. Thus, the skin must be wiped thoroughly during the initial steps.

For 3-lead ECG, place the red electrode below the right clavicle, the yellow electrode below the left clavicle, and the green electrode below the left ribs. Given that PEA can be observed in neonates [36], the heart rates displayed do not necessarily represent effective cardiac output. Thus, the initial heart rate measurement and the first measurement upon return of spontaneous circulation after chest compressions must be performed by auscultation. Auscultation and pulse oximetry measurements should also be used as references to make judgements.

(Hiroshi Mizumoto)

**Key point**

PEA
A condition in which there is no effective cardiac output despite the presence of cardiac electrical activity. Clinically, it must be treated as cardiac arrest. Heart beats cannot be detected by auscultation.

**Fig. 5-14** ECG leads position

# III Ventilation corrective steps

## 1 Insufficient chest movements despite bag-mask ventilation

Resuscitation skills is not only the ability to perform resuscitation procedures according to the algorithm; they also include the ability to quickly solve unanticipated problems occurring during resuscitation (troubleshooting)[37]. In NCPR, where effective ventilation without delay is paramount, the inability to ventilate effectively with bag-mask ventilation must be resolved quickly. This is because chest compressions and medications will not be fully effective without effective ventilation.

### (1) Prepare the equipment Preliminary check of equipment is the first step

The causes of ineffective bag-mask ventilation are diverse. To respond to unexpected situations smoothly and rapidly, thorough preparation of the equipment in advance is necessary to reduce risk factors as much as possible. Preparation of the equipment is not just having enough supplies (quantity); but also checking their function (quality). It should be remembered that shortages or inadequate equipment cause substantial confusion in critical situations such as resuscitation. Resuscitation providers must personally check for any deficiencies of equipment during the briefing.

**Key point**

- Preparation of the equipment requires checking both quantity (the equipment are complete) and quality (the equipment are fully funtional).
- The better prepared you are, the quicker you can solve the problem.

### (2) Three indicators for assessing the achievement of effective ventilation

In NCPR, three indicators are proposed for assessing the achievement of effective ventilation: (1) rising heart rate, (2) chest wall movements, and (3) detection of end-tidal $CO_2$ (**Table. 5-1**). These indicators must be checked constantly while providing ventilation during resuscitation.

The absence of these indicators may indicate that ventilation is ineffective. In that case, the following three steps (**Table. 5-2**) are recommended to solve the problem.

**Table. 5-1** Three indicators for assessing ventilation

| | | |
|---|---|---|
| Method 1 | Heart rate | Bradycardia improves or heart rate increases |
| Method 2 | Chest movements | Chest rises symmetrically in accordance with ventilation |
| Method 3 | End-tidal $CO_2$ | End-tidal $CO_2$ monitor shows a pronounced response to breathing (particularly while the neonate is intubated) |

**Table. 5-2** Three steps

| | | |
|---|---|---|
| 1 | Mask adjustment | Check if mask is the proper size, in the proper position, and tightly sealed to the face |
| | Reposition airways' management position | Confirm that the neonate is properly in the sniffing position |
| | | (shoulder roll: Adjust so that the ears and the top of the shoulders form a straight line) |
| 2 | Oral/nasal suctioning | Check for secretions in the oral and nasal cavities before suction |
| | Increase ventilation pressure | Gradually increase ventilation pressure until both sides of the chest rise. |
| 3 | Consider alternative airway | Consider other ventilation techniques such as laryngeal mask airway insertion and endotracheal intubation |

*Check for any deficiencies of equipment in advance.
*The order of the items in each step does not matter.

## 2 Three steps to solve problems for achievement of effective ventilation

### (1) Mask adjustment and reposition airway

Many problems that occur during bag-mask ventilation are related to the mask fitting and positioning for airway management (sniffing position). Thus, checking these parameters first is the most effective way to solve problems. With flow-inflating bag, a good mask seal can be confirmed by examining the degree of bag inflation. However, with self-inflating bag, the mask fitting cannot be determined by the inflation of the bag even if it is inadequate. As a result, inadequate bag ventilation may continue, resulting in ineffective ventilation. Additionally, when a mask with an air filled cushion is used, it must be pre-filled with an appropriate volume of air to achieve a tight fit of the mask to the face [37)].

The position for airway management may be affected during mask-bag ventilation, even if the neonate is initially positioned appropriately. Furthermore, too much attention to the mask fitness may cause the neonate's head to be tilted forward or backward. Make sure that the position for airway management is well maintained, especially during mask-bag ventilation.

### (2) Suction mouth and nose and increase pressure

The second step in solving problems is performing oral/nasal suctioning and increasing ventilation pressure. Inadequate oral/nasal suctioning during the initial steps interferes ventilation.Tracheal or gastric secretions may accumulate in the oral and nasal cavities during various procedures, and this can be solved by opening the airway with scution.

Additionally, the optimal ventilation pressure varies among individual neonates. A high initial ventilation pressure may be required due to deficiency or decreased activity of pulmonary surfactants, the anatomical structure of the respiratory tract, and alveoli being filled with lung fluids. On the other hand, ventilation with unnecessarily high pressure carries a risk of pneumothorax. If chest movements cannot be seen even after the procedure shown in (1) is performed, try to increase ventilation pressure, but avoid applying excessive pressure. Pressure should be monitored by using a manometer and observing chest movements.

### (3) Consider alternative airway : laryngeal mask airway insertion and endotracheal intubation

If ventilation remains ineffective after completing all of the steps above, a technique other than bag-mask ventilation must be used. If effective bag-mask ventilation is difficult, laryngeal mask airway insertion or endotracheal intubation must be considered, depending on the experience and qualifications of the resuscitation provider.

(Rinshu Shimabukuro)

#### Key points

1 For neonates with secondary apnea, ventilation must be started at the latest within 60 seconds of birth.

2 A rapid increase in heart rate is a sensitive indicator of successful resuscitation.

3 For term neonates or preterm neonates born at ≥35 weeks of gestation, ventilation must be started with room air.

4 For preterm neonates born at <35 weeks of gestation, ventilation must be started with room air or a low oxygen concentration (21%-30%).

5 Central cyanosis must be assessed by observing the color of the lips, tongue, and skin of the trunk, and poor oxygenation must be assessed according to the $SpO_2$ value.

6 Procedures, characteristics, and advantages/disadvantages of resuscitation using a self-inflating bag, a flow-inflating bag, or a T-piece resuscitator must be understood before providing resuscitation.

7 The use of an excessively large mask carries the risk of eye damage and bradycardia associated with a vagal response.

8 When ventilating term neonates, an initial ventilation pressure of approximately 30 $cmH_2O$ (for preterm neonates, 20-25 $cmH_2O$) or higher, and longer inspiratory time may be required.

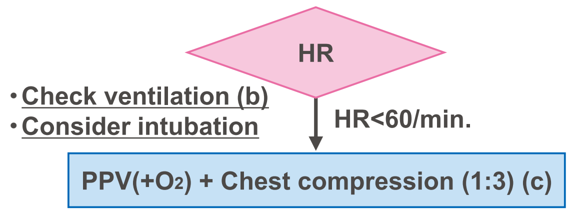
9 The ventilation rate must be 40 to 60 breaths/min. The rate must not exceed 1 breath/s, even in the most urgent situations, to avoid overventilation.

10 Electroencephalogram can display the heart rate more quickly than a pulse oximeter, but the possibility of PEA must be considered.

11 To perform appropriate bag-mask ventilation, the three indicators must be assessed first to confirm effective ventilation, and when the chest movement is inadequate, problems must be solved using the three ventilation corrective steps.

# Assess effectiveness of ventilation and proceed to next step (chest compressions)






(b) If the ventilation is not optimal, focus on improving ventilation before proceeding to the chest compressions.
(c) PPV 30/min. and chest compression 90/min

## I Assessments after ventilation

Heart rate and breathing must be assessed after performing effective ventilation for approximately 30 s. The main cause of bradycardia and cardiac arrest at birth is not cardiogenic; it is secondary apnea due to hypoxia. Thus, if bradycardia (heart rate, <100 bpm) persists even after ventilation, make sure that ventilation is being performed appropriately, for example, by observing chest movements.

Ventilation is stopped when the heart rate exceeds 100 bpm and spontaneous breathing is confirmed. Ventilation should be continued when the heart rate exceeds 100 bpm but spontaneous breathing or effective breathing is not confirmed or when the heart rate is at least 60 bpm but less than 100 bpm. After assessing whether ventilation is being performed appropriately, the need for endotracheal intubation must be considered.

When the heart rate is less than 60 bpm despite effective ventilation, chest compression must be started, and the oxygen concentration should be increased (**Fig. 6-1**). However, if ventilation is performed inappropriately, do not start the chest compression, and focus on ensuring the effective ventilation (see p. 84, STEP 5 III, Corrective ventilation steps).

**Fig. 6-1** Chest compressions coordinated with positive pressure ventilation

# II Chest compressions

## 1 Ratio of ventilations to chest compressions

When bradycardia and cardiac arrest occur, the neonate has severe hypoxia with extremely low oxygen saturation. To revive the neonate in this situation, effective ventilation that restores oxygenation and circulatory support is critical.

When chest compressions are required, one rescue breath should be provided for every three compressions. It takes 2 s to perform each cycle, thus, 90 chest compressions and 30 rescue breaths must be provided in 1 min. In principle, the person performing chest compressions serves as a pacemaker by repeatedly counting aloud "1, 2, 3, bag" (**Fig. 6-2**).

**Key point**

Use oxygen when initiating chest compressions.

## 2 Depth and location of chest compressions

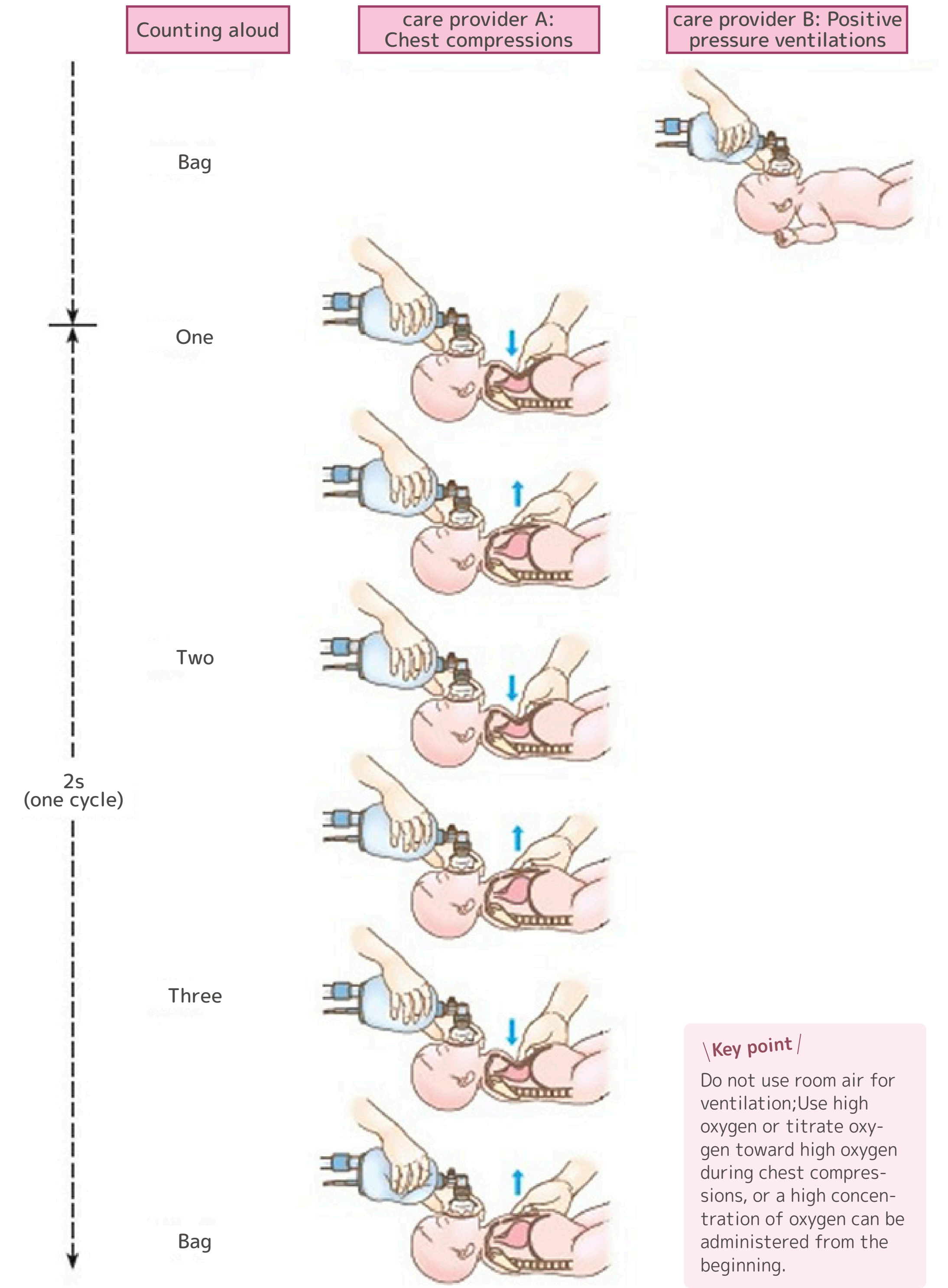
Chest compressions are delivered on the lower third of the sternum because an analysis of chest X-rays has shown that the heart is located there and compressions there produce higher blood pressure than compressions delivered on the middle third of the sternum (**Fig. 6-3**).[38,39]

Deliver compressions to a depth of one-third of the anterior-posterior diameter of the chest.[40] Do not remove the fingers from the chest even when releasing pressure. Ventilation must not be stopped to prepare for chest compressions.

**Key points**

- Ventilation must not be stopped to prepare for chest compressions.
- The person performing chest compressions must adjust the oxygen concentration.

**Fig. 6-2** Timing of ventilations and chest compressions



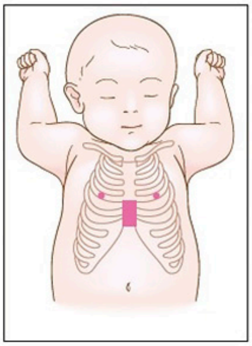

**Key point**

Do not use room air for ventilation;Use high oxygen or titrate oxygen toward high oxygen during chest compressions, or a high concentration of oxygen can be administered from the beginning.

**Fig. 6-3** Chest compressions: Compression with two thumbs with the hands encircling the chest (two-thumb technique)

**a**: Positioning of the two thumbs ■

- Deliver compressions with both thumbs to the lower third of the sternum
- Encircle the chest with the rest of your hands
- Compress to a depth of approximately one-third of the depth of the chest



**b**: Thumb position from above

**c**: Thumb position from the neonate's head

**d**: Chest compression depth (Approximately onethird of the anterior-posterior diameter of the chest)

# 3 Chest compression techniques

## (1) Compression with two thumbs with the hands encircling the chest (two-thumb technique)

The two-thumb technique involves encircling the chest with the two hands placing the thumbs on the chest (**Fig. 6-3**). Compared to the two-finger technique, this technique causes less fatigue and can produce higher blood pressure.[41] In addition, delivering compressions to the lower third of the sternum has the least impact on other organs.[42] Thus, the two-thumb technique is chosen as the first-line approach for chest compressions in neonates. Overlapping the thumbs rather than positioning them adjacent to one another produces greater blood pressure and pulse pressure but should be done with care because it causes greater fatigue.[43]

**Fig. 6-4** Compression with two fingers (two-finger technique)

**a**: Compression with two fingers, the index finger and middle finger

**b**: Correct positioning of two fingers during diastole

**c**: Incorrect positioning of the fingers (do not remove the fingers from the chest, even during diastole)

## (2) Compression with two fingers (two-finger technique)

In the two-finger technique, two fingers, either the index finger and middle finger or the middle finger and the ring finger are used to compress the sternum (**Fig. 6-4a, b**). If the neonate is lying on a soft surface, it is acceptable to place the other hand on the neonate's back instead of using a CPR board. Care must be taken not to remove the fingers from the neonate's chest, even during the diastole phase (**Fig. 6-4c**).

Choose the two-finger technique over the thumb technique in the following situations

- When the umbilical cord has been catheterized to administer drugs (it is not possible to maintain a clean abdominal field with the two-thumb technique)
- When performing resuscitation alone (the same person cannot deliver both ventilations and chest compressions with the two-thumb technique)
- When the provider has small hands

## 4 Assessment after chest compression

The heart rate must be checked every 30 s by either 6-s auscultation or ECG monitoring. Chest compressions must be continued until the heart rate returns to ≥60 bpm. Ventilation must be continued while assessing the heart rate. If the heart rate does not return to ≥60 bpm, the administration of adrenaline, in addition to ventilation and chest compressions, must be considered.

In cases of cardiac arrest or bradycardia requiring chest compression, caution must be taken when interpreting measurements from an end-tidal $CO_2$ detector or a pulse oximeter.

# III Oxygen administration and decreasing oxygen during chest compressions

The oxygen concentration must be increased when starting chest compressions. Although there is no clear standard for the oxygen concentration in this situation, the oxygen concentration should be increased to a high concentration (80%-100%) according to the assessment of the heart rate, skin color, and $SpO_2$, or a high concentration of oxygen (80%-100%) can be administered from the beginning.

According to NCPR2015, the results of animal studies showed that room air can be used during neonatal chest compressions and that there is no benefit to using 100% oxygen, but neither of these findings was supported by adequate evidence. It is recommended that ventilation be started with air for term neonates and with an oxygen concentration of 21%-30% for preterm neonates, and the oxygen concentration must be adjusted based on the $SpO_2$ value [44, 45]. However, there are no data indicating the optimal oxygen concentration during chest compressions.

In fact, when neonates require chest compressions, it is likely that they received ventilation using oxygen that did not improve skin color and $SpO_2$ and that they have severe hypoxia and require oxygen administration.

After chest compressions are started, the heart rate must be assessed roughly every 30 s. Stop chest compressions but continue ventilation if the heart rate increases to ≥60 bpm and stop ventilation if the heart rate increases to ≥100 bpm and the neonate starts breathing spontaneously. The oxygen concentration should be decreased if the $SpO_2$ value exceeds 95% to avoid organ damage due to exposure to a high oxygen concentration.

**\Key point/ How to increasing and decreasing oxygen concentrations**

There is no clear evidence as to the best approach to increasing and decreasing oxygen concentrations. Large-scale studies of oxygen concentration during the initiation of resuscitation in preterm infants show that oxygen concentration is adjusted by approximately 10 to 20% in response to assessments made every 15 to 60 seconds. [46~51] Adjusting oxygen in accordance with assessments of heart rate, skin color, and $SpO_2$ using such a method may be an option. Institutions and individuals should consider, discuss, and decide on specific policies of increasing and decreasing oxygen concentration regularly.

### Chest compression techniques in the future

CoSTR2020 adopts the recommendations of CoSTR2015 without modification, but studies of the coordination of chest compressions with ventilation are underway. Studies of the combination of chest compressions and sustained inflation (the CC+SI method) showed extremely interesting results. Several animal experiments showed that spontaneous circulation returns significantly more quickly with the CC+SI method than with the conventional 3:1 method (in which the ratio of chest compressions to ventilation is 3:1) [52-54]. Additionally, a large-scale prospective controlled study comparing the CC + SI method and the conventional 3:1 method in humans [55] is underway: the results of this study are eagerly awaited.

(Takahiro Sugiura)

### Key points

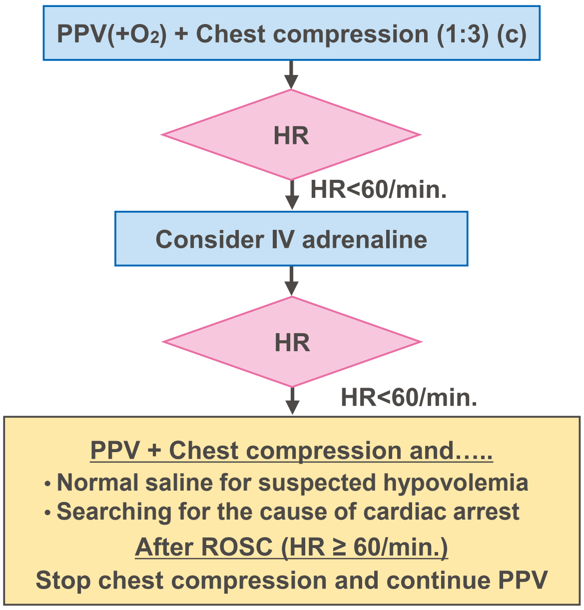
**1** The oxygen concentration must be increased when chest compressions are initiated.

**2** The technique using two thumbs with the hands encircling the chest (two-thumb technique) is the first-line approach for chest compressions.

**3** One rescue breath should be provided for every 3 compressions (2 s per cycle) in a coordinated manner.

**4** The heart rate must be assessed roughly every 30 s, and stop chest compressions but continue ventilation if the heart rate increases to ≥60 bpm.

# Medications




(c) PPV 30/min. and chest compression 90/min

More than 99% of neonates who require CPR can be revived by effective ventilation coordinated with chest compressions of adequate depth delivered at an adequate rate. However, the heart rate remains <60 bpm even with such interventions in approximately 0.05% of neonates who require CPR. Medications are required for the resuscitation of these neonates.

Medications must be provided only when the neonate is receiving effective ventilation using oxygen and chest compressions: ventilation and chest compressions must continue when the neonate is receiving medications [9, 56].

# I Preparation for adrenaline

It is necessary to evaluate whether the heart rate has increased to >=60 bpm after the initiation of oxygen administration. If a proper pulse wave is detected by a pulse oximeter attached to the neonate, use the heart rate displayed on the pulse oximeter. If ECG waveforms are detected by the ECG monitor attached to the neonate, use the heart rate displayed on the ECG monitor.

If the heart rate remains <60 bpm despite with the adequate resuscitation techniques,intravenous adrenaline (Bosmin®) is the first-line intervention. Furthermore, as described below, the umbilical venous route must be considered as the first-line administration route. The peripheral venous route can also be used if a peripheral venous access is secured promptly. If such intravenous administration cannot be secured promptly, the next best approaches to consider are endotracheal administration via an endotracheal tube and intraosseous infusion using an intraosseous needle [57].

# II Route

## 1 Umbilical vein

Umbilical venous access established by the catheterization of the umbilical vein is the fastest and reliable administration route in neonates and is an acceptable route for the direct administration of drugs. It must be noted that, unlike the placement of a long-term catheter, the catheter for resuscitation is not inserted beyond the point where the reflux of blood is observed and is temporarily secured at this point. The drug is injected first, and then the catheter is flushed with normal saline to ensure that the full amount of the injected drug is delivered into the body.

The catheter will be fully fixed after drug administration but can remain temporarily fixed until the resuscitation procedures become less intensive. Fixation procedures will be implemented according to the situation, but care must be taken not to neglect clean technique because of urgency.

## 2 Peripheral venous administration with peripheral venous catheter

This route is the most commonly used in the routine clinical setting, and it can be used instead of the umbilical venous route in neonates when peripheral venous access is secured promptly. However, if securing access is expected to be difficulty due to poor circulation in asphyxiated neonates, the use of another route of administration must be considered promptly. Additionally, as with other routes of intravenous administration, ensure that the catheter is flushed with normal saline after administration [58, 59].

## 3 Endotracheal administration through an endotracheal tube

The advantage of endotracheal intubation is that a care provider experienced in the procedure can complete it more quickly than securing venous access. However, it is necessary to keep in mind that the tracheal route may be less reliable than the intravenous route for drug administration, and thus, a larger dose of the drug must be used than that used intravenously.

For preventing medical accidents, is important to make a clear distinction between drugs that can be administered through an endotracheal tube (adrenaline, pulmonary surfactant) and those that can only be administered intravenously. In addition, some drugs (e.g., adrenaline) may cause false positives in the exhaled $CO_2$ detector, so caution should be taken in the interpretation of the results.

## 4 Intraosseous infusion with an intraosseous needle

The recommended route of drug administration during resuscitation in infants, children, and adults is intraosseous administration and in neonate, the umbilical vein is the most recommended route because of its ease of use and reliability. If insertion of the umbilical vein is difficult and the healthcare provider has sufficient experience with using intraosseous needles, intraosseous administration with intraosseous needle is acceptable (**Figures 7-1 and 7-2**). However, the use of intraosseous needles has been reported [60] to cause complications such as bone fractures and damage due to fluid leakage, so caution should be exercised. All drugs used for intravenous administration can also be administered by intraosseous infusion

**Fig. 7-1** Intraosseous needle

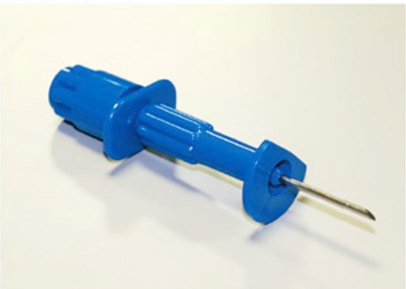
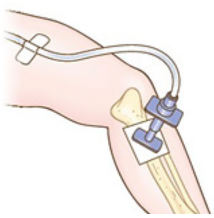


**Fig. 7-2** Sites for inserting (posterior and medial to the tibial tuberosity) and securing the intraosseous needle



# III Medications used for neonatal resuscitation

## 1 Adrenaline (Bosmin®: 0.1% adrenaline)

Adrenaline increases the contractile force of the heart, increases the heart rate, and increases blood flow perfusing the coronary artery and brain to promote contraction of peripheral blood vessels. Only 0.1% adrenaline (Bosmin®) is sold in Japan. Therefore, in clinical practice, one ampule (1 mL) of adrenaline is normally diluted by a factor of 10 using 9 mL of normal saline (10 mL total) to produce 0.01% adrenaline (0.1 mg/mL).

The best route of administration is intravenous. It is recommended to quickly administer 0.01 to 0.03 mg/kg (0.1 to 0.3 mL/kg of the abovementioned diluted solution) intravenously. Administration of higher doses is not recommended. After administering the adrenaline, flush with normal saline to ensure that the entire dose has been administered. For endotracheal administration, which is less reliable than intravenous administration, use a dose of 0.05 to 0.1 mg/kg (0.5 to 1.0 mL/kg of the abovementioned diluted solution). However, even after endotracheal administration is started, the route can be changed to intravenous administration as soon as access is secured, irrespective of the time used for endotracheal administration.

When administering adrenaline, ensure that no drug solution remains in the endotracheal tube or any of the connecting tubes. Start ventilation promptly after administration because the drug will be absorbed through the trachea.

To avoid errors when administering these drugs, devise methods to easily differentiate between intravenous and endotracheal doses, for example, preparing 1-mL syringes with 10-fold diluted Bosmin® for intravenous injection and 10-mL syringes with 10-fold diluted Bosmin® for endotracheal administration, and clearly label each. Check the heart rate approximately every 30 s after administration. If the heart rate is less than 60 bpm, administer a dose of 10-fold diluted Bosmin® within the abovementioned range every 3 to 5 minutes.[58,59)]

**Key point**

Adrenalin administration every 3-5 min, not every 30 s.

## 2 Volume expanders

Consider using a volume expander when the medical history includes placental abruption, placenta previa, umbilical cord hemorrhage, feto-maternal transfusion syndrome, or twin-twin transfusion syndrome or when it appears that resuscitation is inadequate due to hypovolemic shock caused by an obvious drop in circulating blood volume despite unknown medical history. Normal saline is the recommended volume expander to use. Lactated Ringer's solution can also be used, and type O Rh-negative packed red blood cells can be used if the neonate might have had anemia during the fetal period.

Administer 10 mL/kg of normal saline intravenously through the umbilical vein or other appropriate route over a period of 5 to 10 minutes. Administer the same dose again if the response is inadequate. Repeated doses are also administered if massive blood loss can be anticipated. The use of volume expanders is generally not indicated when there is no history of blood loss. However, the use of volume expanders can be considered when another cause is not identified and blood loss cannot be ruled out. [58,59]

## 3 Sodium bicarbonate (Meylon® 8.4%)

The appropriateness of administering sodium bicarbonate is debatable because it poses risks such as intracranial hemorrhage. Nevertheless, consider administering sodium bicarbonate when a neonate has obvious metabolic acidosis despite adequate ventilation management and the acidosis appears to be impeding hemodynamic improvement.

Administration of sodium bicarbonate through an endotracheal tube is contraindicated. Always administer sodium bicarbonate intravenously into a vein that can be checked for flashback. In clinical practice, a commercially available

intravenous preparation such as Meylon® is diluted with distilled water by a factor of two to produce approximately 4.2% sodium bicarbonate solution (0.5 mEq/mL) and injected at a dose of 2 to 4 mL/kg at a rate of at least 1 mL/kg/min. [58,59]

**Key point**

Use distilled water to dilute sodium bicarbonate (Meylon®).

## 4 Preparations for effective pharmacological intervention during resuscitation

To perform effective and prompt NCPR, it is necessary for facilities to establish a system that enables medical staff involved in resuscitation to be familiar with resuscitation knowledge and skills with practical applicability so that the teams can be formed quickly. Providing appropriate resuscitation at the appropriate time is an important element of successful resuscitation. To ensure there are no time delays, preparations for the next stage of resuscitation should always be made when the step currently being performed is ineffective.

As shown in **Table. 7-1**, when administering drugs for neonatal cardiopulmonary resuscitation, it is essential to use the necessary drugs safely and quickly and to have a storage system that ensures that drugs are quickly restocked after use.

Preventing accidents such as medication errors and preparing supplies so that the doses are easy to check are also important in these urgent situations. Specifically, it is necessary to determine in advance the concentrations of drugs, the amounts to be prepared, and the syringes to be used, to always dispense drugs in new syringes, and to save syringes after use as well.

It is also necessary to prepare bulletin boards detailing the dosages and administration for drugs, to have different labels for different drug types, and to create a record form that enables simultaneous recording of the timing of drug administration, the drugs administered, and the doses administered along with the resuscitation procedures that were performed. To prevent infection and needlestick injuries, quick-drying rub-in hand sanitizers and gloves must always be available, facilities must be equipped with disposal containers for used needles, and the adoption of a needleless system should also be considered.[58,59]

(Isao Kusakawa)

**Table. 7-1 Medications for neonatal resuscitation**

| Drug | Dose | Dissolution method used in practice | Recommended syringe | Actual dose |
|---|---|---|---|---|
| Bosmin® (0.1% adrenaline) (1 mg/mL) | Intravenous 0.01–0.03 mg/kg | 1 ml Bosmin® + 9 ml saline (0.1 mg/mL) | 1 mL | 0.1–0.3 mL/kg |
| | Endotracheal 0.05–0.1 mg/kg | 1 ml Bosmin® + 9 ml saline (0.1 mg/mL) | 5 mL/10 mL | 0.5–1.0 mL/kg |
| Normal saline | 10 mL/kg/dose | Stock solution | 20 mL/30 mL | 10 mL/kg/dose |
| Meylon® 8.4% (8.4% sodium bicarbonate) | 1–2 mEq/kg/dose | 5 mL Meylon® 8.4% + 5 mL distilled water (0.5 mEq/mL) | 10 mL | 2–4 mL/kg/dose |

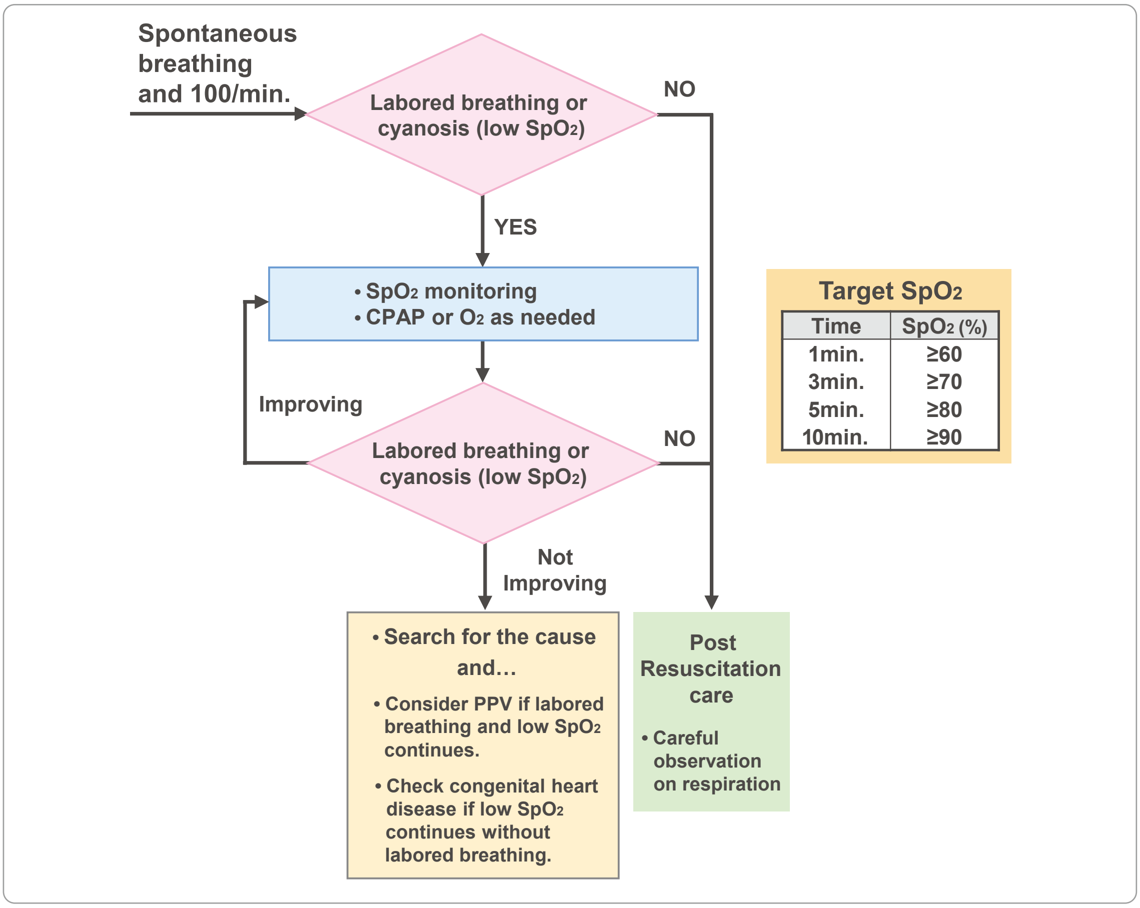
## Key points

1 Resuscitation must be continued even when medications have become necessary.

2 The intravenous route is recommended for medication, and the first-line route is the umbilical venous route. The peripheral venous route, endotracheal administration, and use of an intraosseous needle must be considered according to the situation.

3 Preparation is important to ensure that the resuscitation drugs can be used by any staff member.

# Stabilization of breathing




**Target $SpO_2$**

| Time | $SpO_2$ (%) |
|---|---|
| 1min. | ≥60 |
| 3min. | ≥70 |
| 5min. | ≥80 |
| 10min. | ≥90 |

Next, respiratory status must be assessed, because the confirmation of spontaneous breathing (or crying) and a heart rate of ≥100 bpm does not necessarily indicate stable breathing. In this situation, important indicators are labored breathing and central cyanosis (or poor oxygen saturation) in neonates. Unlike in the rescue sequence on the left side of the algorithm, the neonate is breathing spontaneously, and the heart rate is sustained. Thus, it is not necessary to rush to the next step. When labored breathing and central cyanosis (or poor oxygen saturation) persist, a pulse oximeter must be attached to the neonate and it should be determined whether the provision of CPAP and oxygen administration is necessary.

## I Labored breathing

Once spontaneous breathing (or crying) and a heart rate ≥100 bpm are confirmed, labored breathing is assessed next. Specifically, it is necessary to look for nasal flaring, grunting, and signs of labored breathing (retractions and tachypnea ≥60 breaths/min).

Respiratory distress with nasal flaring alone tends to be mild and often resolves spontaneously, and only careful observation is required in such cases.

Grunting occurs when the glottis is slightly closed while exhaling, which maintains high airway pressure and prevents alveoli from collapsing; in other words, it occurs when neonates themselves generate PEEP[61)]. Thus, grunting indicates a condition in which the alveoli are not easily expanded and are prone to collapse.

Retractions include subcostal, intercostal, sternal, and suprasternal retractions. Mild subcostal retractions can be observed in normal neonates, but others types of retraction generally indicate increased respiratory effort[62)]. Harder inhalation reduces the intrapleural pressure to a greater degree, resulting first in subcostal and intercostal retractions and then in sternal and suprasternal retractions when the pressure reduction becomes more intense.

Gasping must be distinguished from labored breathing. Gasping is an abnormal breathing pattern characterized by irregular, deep, large gasps at a low rate (1 gasp/5-10 s). It is almost always accompanied by bradycardia, and this can be used to differentiate it from labored breathing. It must be noted that gasping is regarded as apnea, not as spontaneous breathing, and thus requires the prompt provision of positive pressure ventilation.

## II Central cyanosis or poor oxygen saturation and attachment of a pulse oximeter

In addition to the assessment of labored breathing, central cyanosis or poor oxygen saturation must be examined. It takes several minutes before skin color and oxygen saturation improve, even in neonates without any underlying conditions. It must be noted that relatively low target $SpO_2$ values soon after birth (≥60% and ≥70% at 1 min and 3 min after birth, respectively), as shown in the algorithm, are completely normal[63-65)]. In other words, central cyanosis that is judged by skin color at only 1-2 min after birth does not require urgent intervention. Given that skin color is not a reliable indicator of central cyanosis, a pulse oximeter must be attached to the neonate when labored breathing is present and central cyanosis persists. It must be noted that it takes 1-2 min or longer for a pulse oximeter to produce reliable $SpO_2$ values. Thus, when respiratory support is likely needed, it is desirable to attach a pulse oximeter to the neonate as soon as possible.

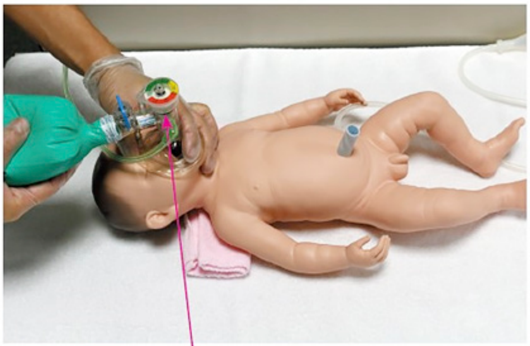
It is also important to assess the presence of central cyanosis and its changes by constantly monitoring skin color until reliable $SpO_2$ values are available for assessing oxygen saturation.

## III CPAP (Continuous Positive Airway Pressure)

When labored breathing and poor oxygen saturation (below the $SpO_2$ target value) persist, the provision of CPAP or oxygen administration must be considered. CPAP is indicated for both labored breathing and poor oxygen saturation, and oxygen administration is mainly indicated for poor oxygen saturation. When the neonate is spontaneously breathing, CPAP applied to the airway helps the lungs expand, especially by preventing the alveoli from collapsing during exhalation. Studies of the use of CPAP for preterm neonates have suggested a possible reduction in mortality and bronchopulmonary dysplasia [66-68], and therefore, it is recommended that CPAP be provided before PPV (**Fig. 8-1**).

The provision of CPAP is recommended for term neonates based on the data obtained from preterm neonates, despite inadequate evidence of its efficacy in term neonates. The use of room air rather than 100% oxygen for resuscitation was shown to reduce mortality in term neonates who required respiratory support [69], and "oxygen administration with utmost care" has been emphasized since NCPR2010 [10]. Therefore, it is reasonable to try CPAP with air first. Additionally, similar to the recommendations when performing positive pressure ventilation, an initial oxygen concentration of 21%-30%, but not

**Fig. 8-1** CPAP



Target pressure of 5 to 6 $cmH_2O$ (do not exceed 8 $cmH_2O$)

higher, is recommended when providing CPAP to preterm neonates [70].

When providing CPAP using a bag-mask device, position the neonate in the supine "sniffing position" (in which the neck is slightly extended, the head is tilted backward, and the chin is lifted) for airway management, as is done when performing positive pressure ventilation, and hold the mask using the IC clamp technique (see p. 80) to make sure to avoid compressing the eyes with the mask. Increases in air leak, such as pneumothorax, due to use of CPAP [66, 71] have been reported; therefore, the pressure inside the airway must be monitored with a manometer or a similar device to maintain a target pressure of 5-6 $cmH_2O$, without exceeding 8 $cmH_2O$, while providing CPAP.

## IV Free-flow oxygen

When poor oxygen saturation persists, consider the administration of oxygen. Oxygen can be administered simultaneously with CPAP, or free-flow oxygen can be administered. Attach a pulse oximeter to the neonate to monitor for excessive oxygen administration, and use an air/oxygen blender to start administration at an oxygen concentration of approximately 30% or lower. Adjust the oxygen concentration by monitoring the $SpO_2$ value to achieve the target $SpO_2$ values for the corresponding time after birth [63-65]. When a blender is unavailable, 100% free-flow oxygen can be used.

Even in such cases, the $SpO_2$ value must be monitored, and the oxygen dose must be adjusted accordingly by adjusting the distance between the neonate's mouth and the oxygen-supplying device and adjusting the flow rate of oxygen.

Free-flow oxygen can be administered with a cupped hand holding a tube or by using an oxygen mask, a flow-inflating bag, or a T-piece resuscitator (**Fig. 8-2**). Noted that it is usually impossible to admin-

**Fig. 8-2** Free-flow oxygen

a: Cupping the hand holding the oxygen tube

b: Using a flow-inflating bag

**Fig. 8-3** Incorrect use of a self-inflating bag

It is usually impossible to administer oxygen using a mask attached to a self-inflating bag.

ister free-flow oxygen securely with a self-inflating bag (**Fig. 8-3**). Certain types of self-inflating bags can be used if they are equipped with a closed-system reservoir or bellows attached to the opposite side of the mask; it is crucial to check beforehand how to use the devices available at individual facilities.

## V When labored breathing and central cyanosis (poor oxygen saturation) persist

When both labored breathing and poor oxygen saturation persist despite the provision of CPAP and the administration of oxygen, search for the cause while continuing to provide these forms of respiratory support. If a worsening trend is observed, consider the initiation of positive pressure ventilation. When only poor oxygen saturation persists despite the absence of labored breathing and the presence of stable spontaneous breathing, consider the differential diagnosis of cyanotic heart disease. When only labored breathing persists, continue to provide CPAP, and then admit the neonates to a neonatal intensive care unit (or a similar unit) or contact an advanced medical institution to discuss transportation of the neonate.

(Tetsuya Isayama)

## Key points

1 When spontaneous breathing or crying are observed and the heart rate is ≥100 bpm, examine the next indicators of respiratory status, that is, the presence or absence of labored breathing and central cyanosis (or poor oxygen saturation).

2 Signs of labored breathing include nasal flaring, grunting, tachypnea (≥60 breaths/min), and retractions.

3 When labored breathing and central cyanosis (or poor oxygen saturation) persist, attach an $SpO_2$ monitor to the neonate and then determine whether CPAP or oxygen administration is required.

4 CPAP is indicated for both labored breathing and poor oxygen saturation, while oxygen administration is indicated mainly for poor oxygen saturation.

5 While providing CPAP, monitor the airway pressure using a manometer or a similar device to maintain a target pressure of 5-6 $cmH_2O$, taking care to keep the airway pressure under 8 $cmH_2O$.

6 Adjust the concentration of oxygen to achieve the target $SpO_2$ values for the corresponding time after birth.

7 When both labored breathing and poor oxygen saturation persist despite the provision of CPAP and the administration of oxygen, search for the cause and consider initiating positive pressure ventilation.

8 When only poor oxygen saturation persists, consider the differential diagnosis of cyanotic heart disease; when only labored breathing persists, continue to provide CPAP and admit the neonate to neonatal intensive care unit (or a similar unit) or an advanced medical institution to discuss transportation of the neonate.

# Post-resuscitation care

## I Thermal management

Neonates easily become either hypothermic or hyperthermic because of the high ratio of body surface area to body volume. Hypothermia (body temperature <36℃ ) and hyperthermia (>38℃ ) after birth are associated with increased neonatal mortality (mortality risk increases by at least 28% with each 1℃ drop in body temperature below 36.5℃ ) [72,73] and morbidity (e.g., intraventricular hemorrhage, pulmonary hemorrhage, hypoglycemia and sepsis) in neonates of all gestational ages.

In NCPR 2020, there is no significant change from NCPR 2015 in the recommendations related to temperature management during resuscitation. An important component of temperature management in NCPR 2015 is to care for monitoring body temperature throughout the algorithm. Based on the notion that inadvertent hypothermia is associated with increased mortality and morbidity in neonates, it is emphasized that optimal maintenance of the neonate's core body temperature (36.5℃-37.5℃) after birth and until admission is crucial.

A literature search did not find any prospective studies on the rewarming rate that have been published since NCPR2015, but two retrospective studies were reported [74, 75]. Both studies compared the rapid (≥0.5℃/h) and slow (<0.5℃/h) rewarming of neonates with inadvertent hypothermia (<36℃) and showed that the rewarming rate did not affect the studies' critical and important outcomes. However, one study suggested that rapid warming might reduce the risk of respiratory distress syndrome [75]. Recommendations on the warming rate for hypothermia may be formulated based on the results of future studies.

However, intervention to prevent hypothermia may cause hyperthermia (>38℃ ) as an adverse reaction. Preventing hyperthermia is just as important because hyperthermia, too is associated with increased neonatal mortality and morbidity.

Therapeutic hypothermia may be indicated for neonates with moderate to severe hypoxic-ischemic encephalopathy (HIE). Thermal management techniques for this intervention are discussed in a later section. However, in all other neonates, it is important to prevent hypothermia and hyperthermia and to maintain an optimum body temperature (core temperature of 36.5 to 37.5℃ ) regardless of what interventions they may require later. It is recommended that temperature after routine care, after resuscitation, and on admission be recorded as an indicator of the quality of care provided to the neonate up to that point and as a predictor of outcomes.

## II Blood glucose management

There has been no changes since NCPR2020 regarding blood glucose management after resuscitation. Consider a intravenous dextrose as soon as possible after resuscitation to avoid hypoglycemia.

Neonates are at high risk for blood sugar abnormalities. Neonates at a high risk of hypoxic ischemia due to neonatal asphyxia are prone to kidney failure, syndrome of inappropriate antidiuretic hormone secretion, and electrolyte imbalances (sodium, potassium, and calcium). Additionally, they sometimes develop post-resuscitation hyperglycemia due to the stress of hypoxic ischemia. Hyperglycemia as well as hypoglycemia can be a cause of neurological damage because hyperglycemia in the post-resuscitation period is associated with neuronal acidosis and oxidative damage. In such cases, insulin production may continue, which may result in hypoglycemia. If hypoglycemia is detected early post-resuscitation, immediate intervention such as intravenous glucose administration is required. The blood glucose level must be monitored until it stabilizes in the normal range. The management of blood glucose and electrolytes is also important in regard to preventing convulsions and arrhythmia and for improving prognosis.

(Takuya Tokuhisa)

## III Therapeutic hypothermia

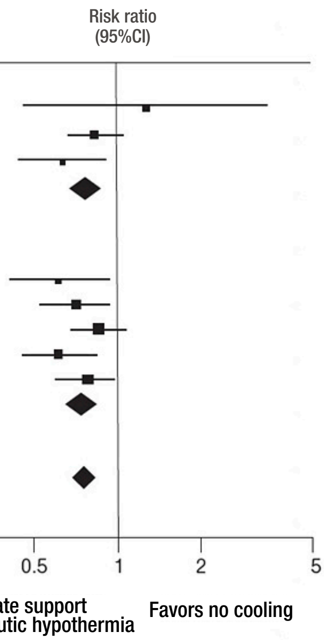
Hypoxic-ischemic encephalopathy (HIE) is a general term for encephalopathy involving exposure of the fetal or neonate brain to hypoxic and ischemic conditions resulting from a trigger such as an interruption of placental blood flow before birth.

An analysis of multiple large clinical trials in neonates born at 36 weeks of gestation or later with moderate to severe HIE, conducted mostly in Western countries, show that starting therapeutic hypothermia (33.5 to 34.5℃ ) within 6 h after birth and adding another treat-

**Fig. 9-1** Comparison of therapeutic hypothermia and no therapeutic hypothermia for moderate or severe HIE

Effect of cooling method on mortality and neurological sequelae in survivors

| | Therapeutic hypothermia | | No Therapeutic hypothermia | | Weight (%) | Risk ratio (95%CI) |
|---|---|---|---|---|---|---|
| | Death or sequelae | Number of cases | Death or sequelae | Number of cases | | |
| **Selective head cooling** | | | | | | |
| Gunn, 1998 | 7 | 18 | 4 | 13 | 1.1 | 1.26 (0.46, 3.44) |
| Cool Cap Study, 2005 | 59 | 108 | 73 | 110 | 17.6 | 0.82 (0.66, 1.02) |
| Zhou, 2010 | 31 | 100 | 46 | 94 | 11.5 | 0.63 (0.44, 0.91) |
| **Subtotal (95%CI)** | | 226 | | 217 | 30.3 | 0.77 (0.64, 0.92) |
| **Total sample size** | 97 | | 123 | | | |
| **Whole-body cooling** | | | | | | |
| Eicher, 2005 | 14 | 27 | 21 | 25 | 5.3 | 0.62 (0.41, 0.92) |
| NICHD Study, 2005 | 45 | 102 | 64 | 103 | 15.5 | 0.71 (0.54, 0.93) |
| TOBY Study, 2009 | 74 | 163 | 86 | 162 | 21.0 | 0.86 (0.68, 1.07) |
| neo. nEURO Study, 2010 | 27 | 53 | 48 | 58 | 11.2 | 0.62 (0.46, 0.82) |
| ICE Study, 2011 | 55 | 107 | 67 | 101 | 16.8 | 0.77 (0.62, 0.98) |
| **Subtotal (95%CI)** | | 452 | | 449 | 69.7 | 0.75 (0.66, 0.84) |
| **Total sample size** | 215 | | 286 | | | |
| **Subtotal (95%CI)** | | 678 | | 666 | 100.0 | 0.75 (0.68, 0.83) |
| **Total sample size** | 312 | | 409 | | | |




(Jacobs SE, Berg M, Hunt R, et al: Cooling for newborns with hypoxic ischaemic encephalopathy. Cochrane Database Syst Rev 2013; 2013 (1) : CD003311. から一部改変)

ment in the NICU significantly decreases mortality and neurological sequelae at 18 months (**Fig. 9-1**).[76] Accordingly, in NCPR2010, therapeutic hypothermia is recommended for moderate to severe HIE.

In 2013, a meta-analysis that included 1,505 cases of moderate to severe HIE confirmed a significant effect of therapeutic hypothermia for reducing mortality and neurological sequelae at 18 months (risk ratio, 0.75; 95% confidence interval, 0.68-0.83)[77]. It was also demonstrated that this effect was maintained in children aged 7-8 years[78, 79]. NCPR2020 also recommends therapeutic hypothermia for neonates born at ≥36 weeks of gestation with moderate to severe HIE.

When a neonate is anticipated to have an indication for therapeutic hypothermia after resuscitation, contact an advanced medical facility that can provide therapeutic hypothermia to discuss transportation of the neonate.

## 1 Indications for therapeutic hypothermia[80]

Contraindications for therapeutic hypothermia are shown in **Table. 9-1**. Therapeutic hypothermia is indicated for neonates who meet both criteria A and B in **Table. 9-2**. Evaluation with amplitude-integrated electroencephalography (aEEG) can also be performed if necessary.

**Table. 9-1** Exclusion criteria for therapeutic hypothermia

| | |
|---|---|
| Contraindications | · neonates more than 6 hours of age at the time of therapy.<br>· neonates with gestational age of less than 36 weeks or birth weight of less than 1800g.<br>· neonates judged by the attending neonatologist as having a major congenital abnormality and unlikely to benefit from therapeutic hypothermia.<br>· unavailability of necessary equipment. |

**Table. 9-2** Inclusion criteria for therapeutic hypothermia

| | Inclusion criteria for therapeutic hypothermia |
|---|---|
| Criterion A<br>Objective findings of systemic hypoxic-ischemic injury | physiological criteria: the presence of one or more signs as follows.<br>· an Apgar score of 5 or less at 10 minutes after birth.<br>· a continued need for resuscitation, including endotracheal or mask ventilation at 10 minutes after birth.<br>· pH of less than 7.00 or a base deficit of 16 mmol/L or more in an umbilical cord blood sample or an arterial or venous blood sample obtained within 60 minutes of birth. |
| Criterion B<br>Subjective findings of encephalopathy<br>It is best to have the neonate examined by a neonatologist or pediatric neurologist knowledgeable about neonatal encephalopathy | neurologic examination<br>· moderate to severe encephalopathy according to criteria modified from Sarnat and Sarnat, such as lethargy, stupor, or coma.<br>· in addition, one or more of the following: hypotonia, abnormal reflexes (including oculomotor or pupillary abnormalities), an absent or weak suck, or clinical evidence of seizures. |
| Criterion C<br>(Optional)<br>Moderate to severe aEEG abnormalities | aEEG (amplitude- integrated electroencephalography) findings: if possible<br>· at least 30 minutes duration, moderate (upper margin >10 $\mu$ V and lower margin <5 $\mu$ V) or severe (upper margin<10 $\mu$ V) abnormal background aEEG voltage, or seizures (a sudden increase in voltage accompanied by narrowing of the aEEG activity band followed by a brief period of burst-suppression). |

There is not enough evidence on the safety and efficacy of therapeutic hypothermia in preterm neonates born at <36 weeks of gestation or neonates with mild encephalopathy.

## 2 Body temperature before and during transportation to another facility

There is insufficient scientific evidence to indicate to what extent the body should be cooled before and during transportation. However, the NCPR2020 recommends that the body temperature of non-asphyxiated neonates be maintained at 37.5℃ or lower. Avoid extreme increases in body temperature (≥38.0°C) before and during transportation.

## 3 Cooling methods and rewarming

Whole-body cooling and selective head cooling are both appropriate. However, the cooling protocol should follow the efficacy and safety guidelines established by large clinical trials (i.e., initiation of cooling within 6 hour of birth, cooling for 72 hour, and rewarming over a period of at least 4 h). There was no clear effect on reducing mortality and neurological sequelae at 18 months when cooling was started at

6-24 h after birth[81]. Furthermore, a lower body temperature (32℃) and lengthy cooling (120 h) increased mortality[82].

Since NCPR2010, instruments enabling the strict adjustment of core and cooling temperatures have become well established for therapeutic hypothermia in Japan. Simplified cooling methods, such as those using cooled gel packs, should not be used in Japan as their safety and supporting evidence have not been sufficiently demonstrated.

## 4 Adverse reactions to cooling

Bradycardia and thrombocytopenia were reported as adverse reactions to cooling.[77]. Neonates must be monitored carefully for signs of hypotension, coagulation disorder, infarction and hemorrhage in major organs, and pulmonary hypertension, but these adverse responses to cooling were not significantly increased in several large-scale clinical studies[77].

## 5 Follow-up

Neonates who receive therapeutic hypothermia require long-term follow-up.

(Jun Shibasaki)

### Key points

1 The key in thermal management during resuscitation is to be mindful of maintaining the neonate's body temperature throughout the algorithm. The target core body temperature at NICU admission is 36.5℃-37.5℃. Each facility must determine the settings temperature at room and incubators according to their circumstance in advance. All items necessary for resuscitation must be prepared.

2 To be mindful of avoiding hypoglycemia in blood glucose management after resuscitation. In post-resuscitation glucose management, be aware of avoiding hypoglycemia. It is important to take immediate action including the administration of intravenous glucose.

3 Therapeutic hypothermia is recommended for neonates born at ≥36 weeks of gestation with moderate to severe HIE. Try to maintain the neonate's body temperature at <38℃ before and during transportation to another medical facility. Cooling should be carried out in a protocol that has been demonstrated to have efficacy and safety in large-scale clinical trials. Bradycardia and thrombopenia have been reported as adverse reactions to cooling. Neonates who receive therapeutic hypothermia require long-term follow-up.

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Chapter

3

# Advanced Neonatal Resuscitation

Chap.3

# Endotracheal intubation

Endotracheal intubation is a simple, quick, and reliable approach to airway management wherever the person in charge is adept at the procedure. However, the procedure itself is inherently invasive, and an inexperienced care provider can cause problems such as mucosal damage, bradycardia associated with vagal response, and hypoxia by attempting to intubate too many times and taking too much time. Endotracheal intubation must be performed only when indicated and only by or with the supervision of someone adept at the technique.

Video laryngoscopy has become widespread in recent years but is not yet commonly used in perinatal clinical practice. For this reason, video laryngoscopy is not explained in detail here and is instead introduced briefly at the end of this section. Interested readers are advised to refer to relevant medical books or journals

## I Indications and timing for endotracheal intubation

Indications for neonatal endotracheal intubation are shown in **Table. 1**, and the timing is shown in **Fig. 1**. In most cases, securing the airways and providing bag-mask ventilation produce effective ventilation, allowing for a gradual, measured approach. The most common situations when intubation would be indicated are:

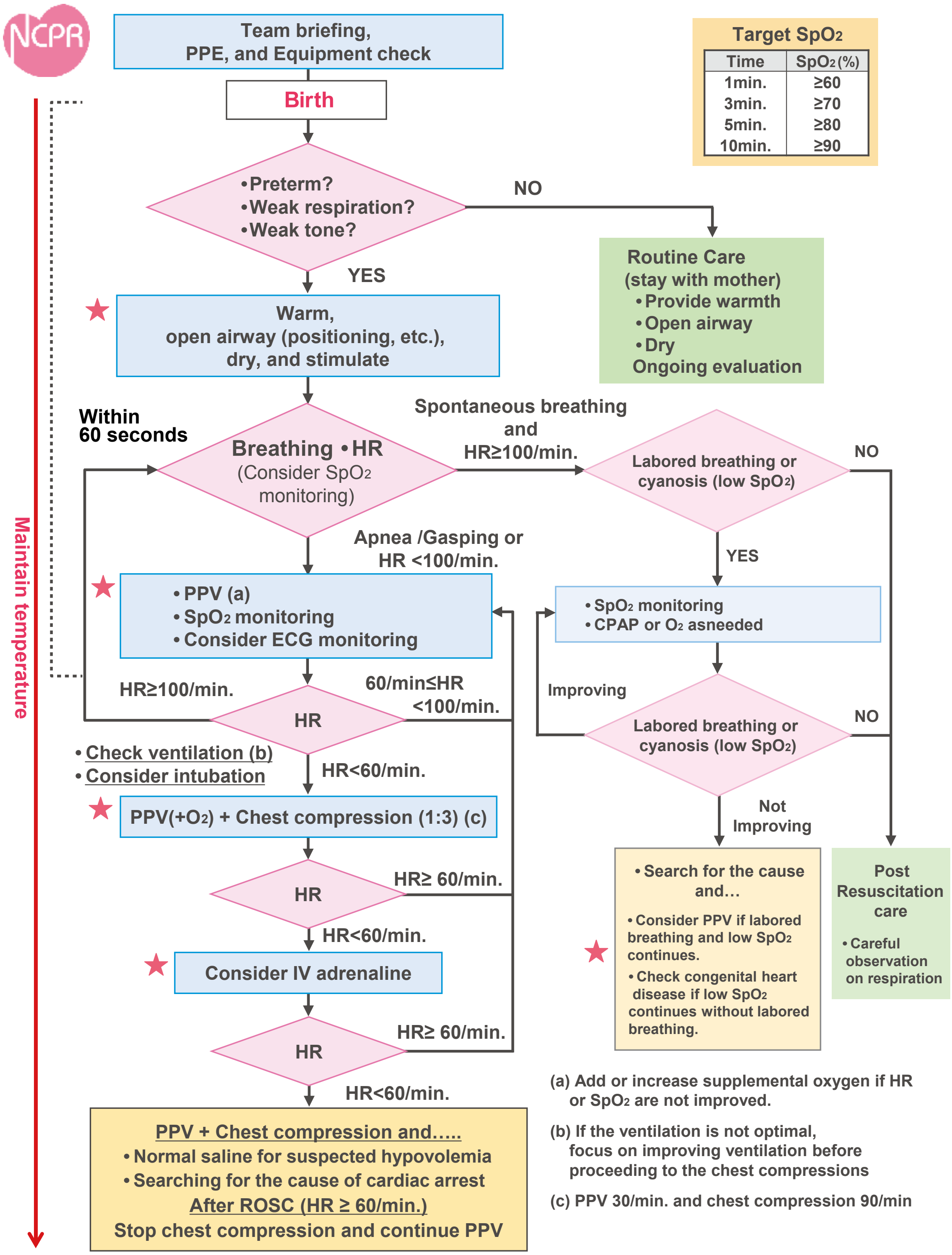
(1) When there are no favorable chest movements despite proper positioning of the neonate, good fit of the mask, and adequate ventilation pressure, when prolonged ventilation is required, or when ventilation does not lead to sufficient clinical improvement. Specific situations are as follows:

**Table. 1** Indications for endotracheal intubation

| | |
|---|---|
| 1 | Heart rate is still less than 100/min at about 30 s after starting effective ventilation |
| 2 | Not only ventilation but also chest compressions are continued for a long period of time |
| 3 | Adrenalin will be administered endotracheally through an endotracheal tube |
| 4 | The neonate meets the criteria for resuscitation, the amniotic fluid is meconium-stained, and tracheal suctioning of meconium could be an effective method of opening the airway |
| 5 | The neonate appears to have certain conditions such as congenital diaphragmatic hernia or respiratory distress syndrome requiring surfactant replacement therapy |

**Fig. 1** Timing of endotracheal intubation

Consider endotracheal intubation at the time points marked with the ★




| Time | $SpO_2$(%) |
|---|---|
| 1min. | ≥60 |
| 3min. | ≥70 |
| 5min. | ≥80 |
| 10min. | ≥90 |

(a) Add or increase supplemental oxygen if HR or $SpO_2$ are not improved.

(b) If the ventilation is not optimal, focus on improving ventilation before proceeding to the chest compressions

(c) PPV 30/min. and chest compression 90/min

☆Heart rate of less than 100/min at approximately 30 s after starting effective ventilation.

☆Ventilation and chest compressions are continued for a long period of time.

If chest compressions are required for a long period of time, intubation may help to maximize the efficiency of the ventilation by coordinating the rhythm of chest compressions and ventilation.

(2) If the heart rate is less than 60 bpm even after adequately performed resuscitation, adrenaline is required, and intravenous administration is the first choice of administration route. However, if the venous route cannot be secured, the endotracheal route (via an endotracheal tube) may be selected as the second choice.

(3) When a neonate who was born through meconium-stained amniotic fluid requires resuscitation based on criteria assessed immediately after birth and insufficient ventilation is anticipated because of likely airway obstruction by meconium,

(4) If the neonate appears to have certain conditions such as congenital diaphragmatic hernia or respiratory distress syndrome requiring surfactant replacement therapy.

In any of these situations, providers unfamiliar with intubation should focus on providing effective bag-mask ventilation rather than wasting precious time attempting intubation.

## II Supplies for endotracheal intubation (Table. 2)

(1) Prepare an aspirator along with a mouth suction tube (10 Fr or wider) and tracheal suction catheter (5 Fr, 6 Fr, or 8 Fr).

(2) Bag and mask: It is possible to administer either low or high oxygen with a self-inflating bag either with or without an oxygen reservoir. When using a flow-inflating bag, it is recommended to adjust oxygen concentrations using a blender and to monitor airway pressure with a manometer.

**Table. 2** Supplies for endotracheal intubation

| Equipment | Monitoring devices | General supplies for resuscitation | Supplies for intubation |
|---|---|---|---|
| Oxygen pipe<br>Oxygen cylinder<br>Compressed air<br>Flowmeter and blender<br>Suction pipe and aspirator<br>Radiant warmer | Pulse oximeter<br>ECG monitor<br>End-tidal $CO_2$ monitor<br>Manometer | Bag (self-inflating bag, flow-inflating bag)<br>Mask<br>Stethoscope<br>Towels<br>Airways<br>Gloves | Endotracheal tube<br>Laryngoscope<br>Straight blade<br>(Stylet)<br>Tape for securing tubes |

(3) Oxygen: The oxygen gas in typical oxygen cylinders is dry. Be cautious of airway drying when providing long period ventilation. Whenever possible use a humidifier.
(4) Laryngoscope: Blade No. 0 (for neonates) or No. 00 (for premature infants) When intubating neonates, the epiglottis is lifted directly with the blade. Always use a straight blade.
(5) Endotracheal tube: Choose the size depending on body weight (**Table. 3**).Prepare tubes with an internal diameter of 2.0, 2.5, 3.0, and 3.5 mm. Always have three sizes ready, the size appropriate for estimated body weight and the larger and smaller sizes.
(6) Various monitors: Pulse oximeter, ECG monitor, end-tidal $CO_2$ monitor
(7) Stethoscope (neonatal stethoscope if available)
(8) Stylet (optional): When using, do not advance the tip of the stylet past the tip of the tube. Caution must be exercised when using a stylet, because the straightened endotracheal tube tends to impede the view during intubation.
(9) Oral airway

## Size and depth of endotracheal tube

Prepare an endotracheal tube with an internal diameter between 2.0 and 3.5 mm that corresponds to estimated body weight (**Table. 3**) Always use an uncuffed tube.

Insert the endotracheal tube so that the thick mark (vocal cord guide), located approximately 1.5 to 2 cm from the tip of the tube, approaches the glottis. Research has shown that 6 cm plus body weight (in kg) can serve as an index for insertion length (in cm) from the lips.

### Insertion depth of the endotracheal tube in extremely low birth weight neonates

Caution must be exercised when caring for neonates with extremely low birth weight, especially those weighing <750 g. Several studies have shown that an insertion depth of 6 cm plus body weight (in kg) is excessive. Among them, a Japanese study provided an approximate guideline of shortening the insertion length by 1 cm for every 300 g below 1000 g, i.e., 5 cm for 400 g, 6 cm for 700 g, and 7 cm for 1000 g [3].

**Table. 3** Supplies for endotracheal intubation

| Body weight (kg) | Gestational age | Tube size (mm) | Insertion depth from the corner of the mouth 6 + body weight (kg)cm |
|---|---|---|---|
| <1.0 | <28 | 2.0 · 2.5 | 5.0 ~ 7.0 |
| 1.0 ~ 2.0 | 28 ~ 34 | 2.5 · 3.0 | 7.0 ~ 8.0 |
| 2.0 ~ 3.0 | 34 ~ 38 | 3.0 · 3.5 | 8.0 ~ 9.0 |
| 3.0< | 38< | 3.5 | 9.0< |

## III Intubation procedure

(1) Achieve adequate oxygenation with bag-mask ventilation (however, intubate without providing ventilation if intubation and suctioning are indicated due to meconium aspiration or when intubating for diaphragmatic hernia).

(2) Place the neonate in the basic position for intubation, similar to that used for bag-mask ventilation (the, sniffing position with the midline of the head placed on a flat surface and the neck slightly extended) (**Fig. 2**).

(3) Hold laryngoscope in the left hand and the neonate's face with the right hand. Use the right hand to open the mouth. When doing so, do not grip the laryngoscope with the entire hand as when intubating children and adults but rather with three fingers (the thumb, first and second fingers). This ensures that no excessive force is used and the procedure is gentle.

(4) When using a straight blade, advance the blade to where the tip pushes directly on the epiglottis right in the middle of the base of the tongue (**Fig. 3**).

Caution: It is usually difficult to advance the tip of a curved blade to the epiglottic vallecula in neonates.

(5) Lift the blade slightly and with it lift the tongue to expose the pharyngeal area. When lifting the blade, lift the entire blade in the direction indicated on the handle. Do not lift the tip of the blade alone (**Fig. 4**).

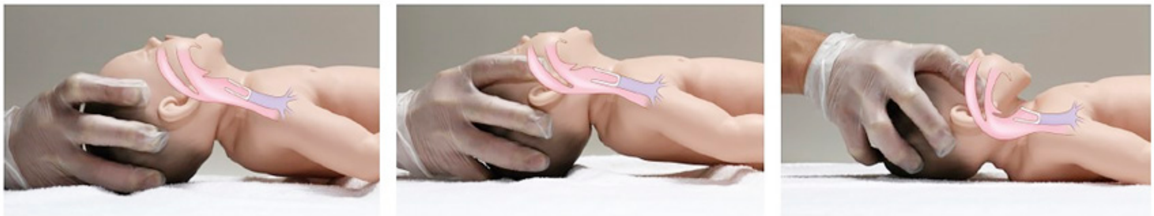
(6) Look for anatomical landmarks (**Fig. 5**). If the tip of the blade is properly depressing the epiglottis, the larynx should be visibly open. The vocal cords should look like vertical stripes on both sides of the larynx, or like an inverted V. If these structures are not visible, immediately adjust blade placement until they are visible.

**Fig. 2** Positioning for intubation

○ Correct:
Position does not impede visibility (lift the tongue with the laryngoscope blade)

✕ Incorrect:
Position impedes visibility (neck overextended)

✕ Incorrect:
Position impedes visibility (neck flexed)



Applying downward pressure on the cricoid cartilage (the cartilage that covers the larynx) may help bring the larynx into view (**Fig. 6**).

The care provider performing the procedure can either apply pressure using the little finger or ring finger or can have an assistant do it. Suctioning secretions also improves visibility. Attempting to intubate while the larynx is not fully visible is the most common cause of failed intubation.

(7) Insert the endotracheal tube. Hold the tube in the right hand and insert from the right corner of the neonate's mouth while keeping the curve of the tube horizontal. This ensures that the tube will not impede the view of the larynx. When the vocal cords open, insert the tip of the endotracheal tube until the vocal cord guide (**Fig. 7a**) reaches the vocal cords while keeping the larynx visible.



**Fig. 3** Anatomical landmarks to reference when positioning the laryngoscopes [4)]

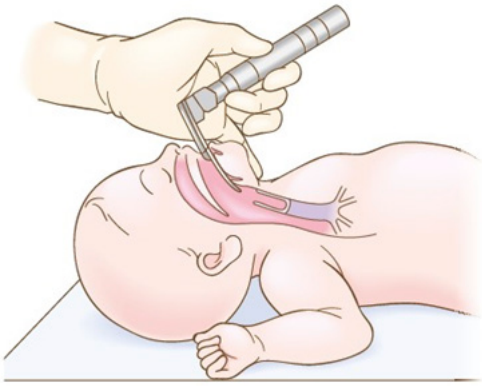
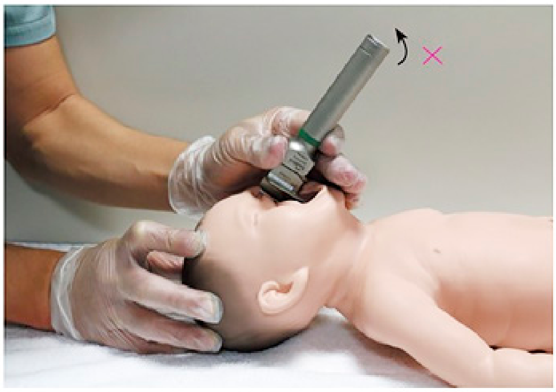


**Fig. 4** Inserting the laryngoscope blade

○ Correct:
Lift the tongue and the jaw.

× Incorrect:
Do not lift the tip of the blade alone and pull up on the handle.

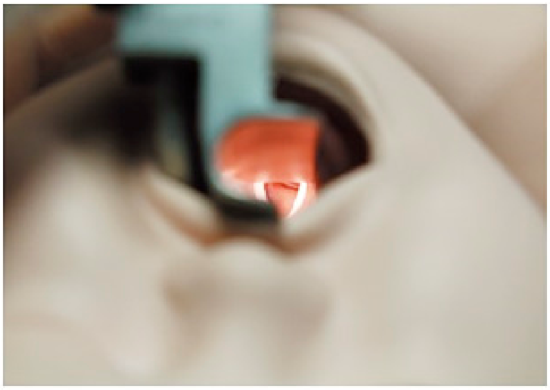


Be sure to only advance the tube to the point where the vocal cord line reaches the vocal cords. The tip of the tube should be almost between the vocal cords and the carina.

When using a stylet, its position should be adjusted so that the distal tip does not protrude from the endotracheal tube, and the proximal end should be bent to prevent it from slipping down while procedures are being performed (**Fig. 7b**). It must be also noted that, as described previously, the view is impeded if the entire endotracheal tube is straightened when a stylet is used.

(8) After intubation, carefully withdraw the laryngoscope while keeping the tube securely in place with the right hand. Secure the tube with tape or another securing device. Refer to the rightmost column in **Table. 3** for the general length of tube to secure at the corner of the mouth.

**Fig. 5** Anatomical landmarks to reference before Inserting an endotracheal tube



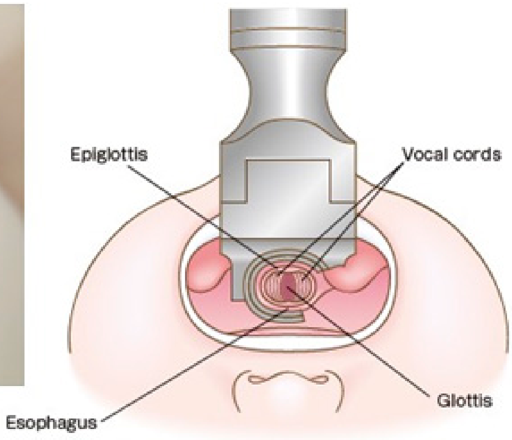
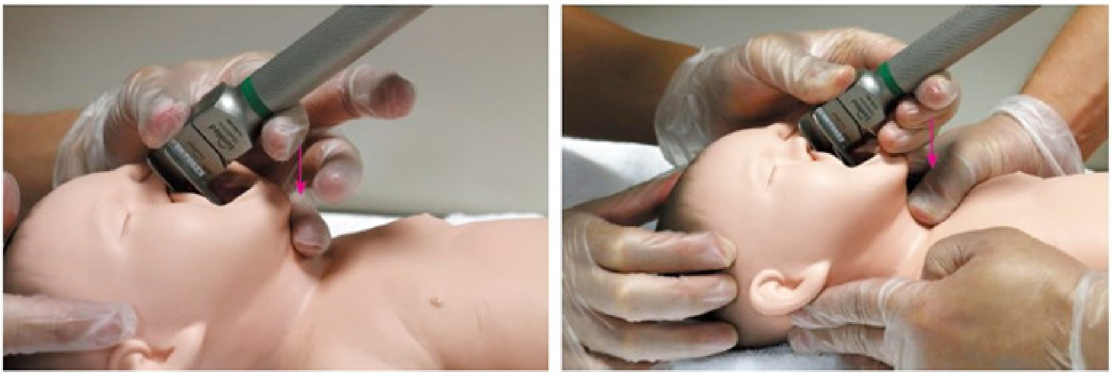



**Fig. 6** Thyrold and cricold pressure

Compressing the larynx from above improves visibility.
This can be done by either the handler (left) or an assistant (right).

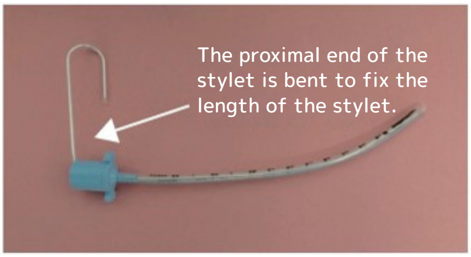


Photographs and key points of endotracheal intubation procedures are shown in **Figure 7**. In principle, an endotracheal tube must be inserted through the mouth during neonatal resuscitation. A laryngoscope designed for use in neonates with a straight blade (size 0 or 00; **Fig. 7c, d**) should be used.

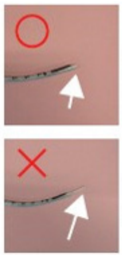
When inserting the endotracheal tube, ensure that a pulse oximeter is attached to the neonate. Carefully watch for decreases in heart rate and/or $SpO_2$, and do not perform any procedures forcefully; intubation must be performed after sufficient bag-mask ventilation (except when suctioning meconium or when the neonate has a diaphragmatic hernia). If insertion of the endotracheal tube is not completed within 30 s, or if obvious deterioration of the heart rate and/or $SpO_2$ is observed, perform adequate bag-mask ventilation and then try again to insert the endotracheal tube (**Fig. 7e-h**).

**Fig. 7** Endotracheal Intubation


**a**: Vocal cord mark on the endotracheal tube




**b**: Proper use of stylet



The stylet tip is kept inside the endotracheal tube.

The stylet tip is extended outside the endotracheal tube.

**c**: Laryngoscope for use with neonates and neonates (straight blade, size 0 and 00)

**d**: Holding the laryngoscope

f: Holding the neonate for endotracheal intubation

e: Holding the neonate for endotracheal intubation

g: Positioning for intubation

h: Tube insertion
Insert the endotracheal tube from the right corner of the mouth.

## IV Causes and solutions of intubation problems

Causes and solutions of intubation problems are shown in **Table. 4.**

**Table. 4** Intubation problems and solutions

| Situation | Problem | Solution |
|---|---|---|
| Blade not visible due to tongue blocking | Tongue not moved out of the way on insertion | Move the tongue from the right and re-insert the blade |
| Tongue visible in front of blade | Blade insertion not far enough | Advance the blade farther |
| Epiglottis hanging in front of blade | Blade has not reached epiglottis | Place blade on epiglottis and lift again |
| Esophagus visible in front of blade | Blade inserted too far | Slowly withdraw the blade keeping the same angle |
| Opening of the trachea and vocal cords visible on left or right side only | Blade slipped off center to the left or right on insertion | Shift the larynx left or right from the outside using the little finger or ring finger of the left hand |
| Only the lower half of the tracheal opening and vocal cords are visible | Tongue and jaws not lifted high enough | Lift tongue and jaws up or provide thyroid and cricoid pressure |

# V Complications related to intubation

Complications related to intubation are shown in **Table. 5.**

**Table. 5** Complications related to intubation

| Complication | Cause | Prevention and management |
|---|---|---|
| Hypoxia | Excessive duration of intubation<br><br>Tube mal positioning | Provide adequate oxygenation before intubation (prevention)<br>Monitor during intubation (prevention)<br>Take no more than 20 seconds to intubate (prevention)<br>Check with end-tidal $CO_2$ monitor (prevention)<br>Check insertion depth (prevention) |
| Bradycardia | Hypoxia<br>Vagal response caused by intubation procedures | Ensure adequate oxygenation by ventilation (management)<br>Intubate quickly (prevention) |
| Pneumothorax | Unilateral pulmonary overinflation due to unilateral lung intubation<br><br>Excessive ventilation pressure | Insert to proper depth (prevention)<br>Check for equal breathing sounds i.e. respiratory sounds in left and right lungs (prevention)<br>Use correct ventilation pressure (prevention)<br>Transillumination (diagnosis)<br>Chest drainage (management) |
| Oral/respiratory tract injury | Aggressive handling of the laryngoscope blade and/or endotracheal tube | Practice and master gentle handling techniques (prevention) |
| Perforation of trachea or esophagus | Aggressive handling of endotracheal tube Improper use of stylet | Handle equipment gently (prevention)<br>Follow procedures properly (prevention) |
| Obstruction of endotracheal tube | Bent tube<br>Obstruction by secretions or meconium | Check and suction with suction catheter (management)<br>Remove and re-insert endotracheal tube (management) |
| Infection | Unsanitary handling of equipment | Wash hands (prevention)<br>Wear gloves (prevention) |

## VI Confirmation of appropriate endotracheal intubation

When performing endotracheal intubation, the care provider must use the technique indicated for the instruments used and the situation encountered. To confirm that endotracheal intubation was performed properly, always check for the following indicators of proper placement of the tip of the tube after intubation (**Table. 6**).

(1) Both sides of the chest rise and fall simultaneously
(2) Respiratory sounds auscultated at the same strength in lung fields in both axillary regions
(3) No sound of air entering the stomach
(4) No gastric distention
(5) "Water vapor" produced by breathing visible in the tube
(6) Neonate's heart rate, color, and vigorousness improved
(7) Expired $CO_2$ observed (**fig. 8**)

**Table. 6** Assessing outcomes of endotracheal Intubation

| |
|---|
| **Physical findings, etc.**<br>(1) Both sides of the chest rise and fall in concert<br>(2) Respiratory sounds auscultated at the same strength in lung fields in both axillary regions<br>(3) No sound of air entering the stomach<br>(4) No gastric distention<br>(5) "Water vapor" produced by breathing visible in the tube<br>(6) Neonate s heart rate, color, and vigorousness improved |
| **Monitors, etc.**<br>(1) Expired $CO_2$ detected by end-tidal $CO_2$ monitor or $CO_2$ detector (however, $CO_2$ will not be detected if there isnno effective cardiac output due to a cause such as cardiac arrest)<br>(2) Improvement in heart rate and oxygen saturation on pulse oximeter<br>(3) Improvement in heart rate on ECG monitor<br>(4) Position of endotracheal tube observed on chest X-ray films |

**Fig. 8** End-tidal $CO_2$ detector

The color changes from purple to yellow as the $CO_2$ concentration increases.


**Key point**

If ventilation is successful in the presence of pulmonary circulation, the $CO_2$ concentration of the exhaled gas via the endotracheal tube will increase, and the color of the detector will change from purple to yellow with each ventilation.

[Problems]

1 The presence of pulmonary circulation is required.
2 Rapid decision-making is not possible in some cases because $CO_2$ may not be detected until ventilations are performed repeatedly.
3 The detection rate decreases after adrenaline administration.

# VII Video laryngoscopy

Video laryngoscopy offers a better field of view than simple laryngoscopy and enables the operator to share the laryngoscopic view with other personnel, and it has become widely used in the treatment of children and adults in recent years. There are several types of video laryngoscopes, including those that offer a fiber optic view from the tip of the blade and those that offer views from a camera receiver attached to the tip to provide images.

There are two types video laryngoscopes, classified according to their shape: one has the shape of a conventional laryngoscope, and the other is called an airway device. However, neither type is commercially available in a size suitable for use with low birth weight neonates. Thus, a conventional laryngoscope with an image-recording device attached is most often used for neonates. Although they occupy a slightly different category than laryngoscopes, a fiberscope-type device that employs a bronchial fiber as a guide during intubation is also used.

Video laryngoscopy has many advantages, especially educational advantages, such as the ability to share the laryngoscopic view between the operator and others (e.g., an instructor) and the ability to use recordings for review. However, as described earlier, there are disadvantages to their use in the clinical setting, including that blades are available only in certain sizes; the equipment is bulky, which restricts its use in an incubator; and the equipment is somewhat expensive. Once these disadvantages are addressed through new developments, video laryngoscopy is expected to become widely used in the near future. However, procedures vary depending on the equipment, and thus, adequate training is important to ensure that operators are familiar with the equipment that they use.

(Isao Kusakawa)

## VIII Laryngeal mask insertion (Fig. 9)

When ventilation with a face mask is not effective in neonates born at ≥34 weeks of gestation, laryngeal mask airway insertion can be considered instead of endotracheal intubation.

Laryngeal mask airway insertion is sometimes beneficial in airway management when endotracheal intubation is difficult due to micrognathia or macroglossia.

The smallest laryngeal mask airway size can be used for neonates weighing ≤5 kg. The conventional procedure for inserting a laryngeal mask airway is shown below. Several types of laryngeal mask airways are available, and operators must read the relevant instructions carefully and familiarize themselves before use.

(1) Deflate the cuff before insertion (if the laryngeal mask airway is cuffed).

(2) Keep the neonate in the sniffing position.

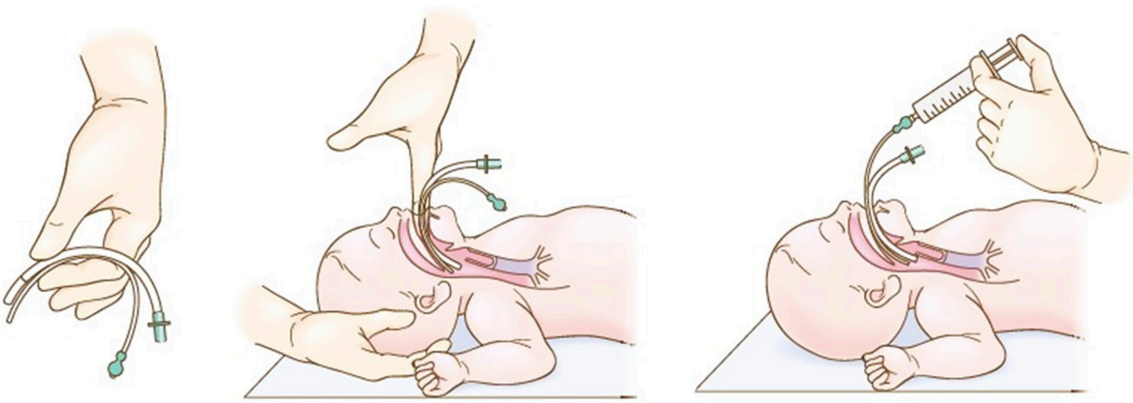
(3) Place the index finger on the mask aperture and hold the laryngeal mask airway with two fingers.

(4) Open the neonate's mouth using the other hand, and, using the index finger, insert the laryngeal mask airway along the hard palate until it meets resistance. Insertion should never be forceful.

(5) Remove the index finger while supporting the tube with one hand.

(6) Inflate the cuff with the designated amount of air (if the laryngeal mask airway is cuffed).

**Fig. 9** Laryngeal mask (LMA) insertion



(7) Similar to the process for inserting an endotracheal tube, confirm that the tip of the laryngeal mask airway is in the appropriate position by auscultation and by observing chest movements upon pressurization. Additionally, and similar to the process used when inserting an endotracheal tube, the detection of expired $CO_2$ with an end-tidal $CO_2$ monitor or a capnometer is the most reliable indicator of successful airway opening with the laryngeal mask airway.

(8) Secure the laryngeal mask airway with a piece of tape.

(Hiroshi Mizumoto)

Chap. 3

## Key points

1 If an experienced staff member is available, perform endotracheal intubation without hesitation. If not, focus on providing effective bag-mask ventilation.

2 Endotracheal intubation must be performed after sufficient bag-mask ventilation has been performed with a pulse oximeter attached to the neonate.

3 After intubation, it is important to confirm that the tube is inserted appropriately.

4 When ventilation with a face mask is not effective in neonates born at ≥34 weeks of gestation, laryngeal mask airway insertion can be considered instead of endotracheal intubation.

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# Resuscitation of preterm infants

## I Cord clamping and cord milking

In Consensus 2015,[1] delayed cord clamping for longer than 30 s is suggested for preterm infants not requiring immediate resuscitation. However, delayed cord clamping is difficult to perform for preterm infants born at 28 weeks of gestation or less who require resuscitation. Therefore, cord milking is determined to be a reasonable alternative that does not impede resuscitation in such neonates.

Given the level of health care in Japan, there is no evidence supporting the need for placental blood transfusion for all preterm neonates. However, based on a multicenter study conducted in Japan[4], one-time umbilical cord milking in which the umbilical cord is clamped and cut 30 cm from the neonate and the cord is milked once under a radiant warmer is recommended for preterm neonates born at ≤24-28 weeks of gestation[3]. The neonate is transferred to the radiant warmer and the umbilical cord must be held straight up so that the umbilical blood flows down naturally: because the umbilical cord is usually twisted, it is important to untwist it before milking[4].

On the other hand, umbilical cord milking is not recommended in the AHA 2020 guidelines for neonatal resuscitation[5] because Katheria et al. reported an increase in the frequency of intracranial hemorrhage with repeated milking before umbilical cord clamping[6], which is a commonly practice worldwide. Thus, caution must be exercised when performing umbilical cord milking. That study analyzed neonates born at ≥23 weeks of gestation but did not compare the frequency of intracranial hemorrhage between umbilical cord milking and delayed umbilical cord clamping by gestational age. However, an article published in Hot Topics in Neonatology® in 2019 showed a significantly higher frequency of intracranial hemorrhage in neonates born at 23 weeks of gestation, but not in those born at ≥24 weeks of gestation[7]. Furthermore, there were no significant differences in the composite outcome of death and severe intraventricular hemorrhage (Grade III or IV) between the two groups.

## II Warming and maintaining temperature

The recommendations in CoSTR2020 [2)] have not changed because the review was based on an Evidence Update(EvUp) rather than a Systematic Review(SysRev), and the recommendations in NCPR2010 and NCPR2015 are also maintained in NCPR2020. Specifically, it is recommended that when treating preterm neonates born at ≥28 week and <32 weeks of gestation under a radiant warmer, the ambient temperature must be maintained at 23-25℃, and a combination of a warmed blanket, plastic wrap, thermal mattress, and/or similar methods must be used to avoid hypothermia (body temperature <36℃) upon NICU admission. It is also recommended to avoid the risk of hyperthermia (body temperature >38℃).

For the resuscitation of a neonate born at <28 weeks of gestation, it is recommended to keep the delivery room temperature at ≥26℃, wrap the neonate's whole body with plastic wrap, and treat the neonate under a radiant warmer.

The need to dry the skin before wrapping the neonate has not yet been proven scientifically, and thus, this matter can be discussed within individual institutions.

## III Continuous positive airway pressure (CPAP) for neonates with labored breathing

In CoSTR2020, CPAP and sustained lung inflation were reviewed based on an EvUp. As a result, CPAP, but not sustained lung inflation, is supported as it was in CoSTR2015; thus, there are no changes in the recommendations. As in NCPR2015, the provision of CPAP at 5 $cmH_2O$ before endotracheal intubation and ventilation is recommended for preterm neonates with labored breathing in the delivery room. However, for neonates who are not breathing spontaneously, there is no need to routinely perform sustained lung inflation for ≥5 s to inflate the lungs at birth.

## IV Ventilation strategy

If ventilation is indicated for a preterm infant, start with an initial inspiratory pressure of 20 to 25 $cmH_2O$ and adjust the ventilation pressure in accordance with indicators such as chest movements.

PEEP use continues to be recommended in CoSTR2020 after the review based on an EvUp (NCPR recommends PEEP of 5 $cmH_2O$). Based on a SysRev of the oxygen concentration at the initiation of ventilation, it is recommended to use a low oxygen concentration (21-30%) when initiating ventilation and to adjust the oxygen concentration using the $SpO_2$ value as an indicator. The ventilation rate must be 40-60 breaths/min. Excessive chest movements should be avoided when performing ventilation, but if the heart rate and/or chest movements do not improve promptly, the pressure needs to be increased.

(Shigeharu Hosono)

### Key points

**1** When preterm neonates born at ≤28 weeks of gestation require resuscitation, umbilical cord milking is recommended instead of delayed clamping. One-time umbilical cord milking is the recommended method.

**2** For neonates born at <28 weeks of gestation, it is recommended to keep the delivery room temperature at ≥26℃, wrap their whole body with plastic wrap, and treat them under a radiant warmer.

**3** For preterm neonates with labored breathing immediately after birth, it is recommended to provide CPAP at 5 $cmH_2O$ before ventilation.

**4** For preterm neonates who require ventilation during resuscitation in the delivery room, it is recommended to use an initial inspiratory pressure of 20-25 $cmH_2O$, PEEP, and a low initial oxygen concentration (21-30%). The ventilation pressure should be adjusted by observing chest movements, and the oxygen concentration should be adjusted by using the $SpO_2$ value as an indicator.

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# Other recommendations regarding neonatal resuscitation



## I Maternal hyperthermia and hypothermia

Maternal hyperthermia may increase the needs for neonatal resuscitation.

Neonates born to febrile mothers are reported to exhibit a higher rate of respiratory disturbances and seizures during the neonatal period, cerebral palsy and have a higher mortality rate. There is no scientific evidence to indicate whether fever itself or other issues increase the risk to the neonate.

There is insufficient scientific evidence to support or refute whether the routine reduction of maternal body temperature is effective in lowering mortality. Nevertheless, maternal hyperthermia may increase the needs for neonatal. Moreover, although there is no evidence that maternal hypothermia poses a significant risk to the neonate, normal body temperature should be maintained to avoid iatrogenic hyperthermia or hypothermia.

**Key point**

Maternal hyperthermia increases the risk that neonates will require resuscitation.

## II Considering termination of resuscitation

Specific criteria for withholding resuscitation were listed in CoSTR2005, such as gestational age <23 weeks, bodyweight <400 g, trisomy 13, and trisomy 18. However, based on the notion that treatment for neonates at the limit of viability vary substantially by region and according to health care resources, CoSTR2010 provided only a general statement that it is ethical to withhold resuscitation when early death or unacceptable burden are expected based on the gestational age, body weight at birth, and congenital anomalies. This expression more closely reflects the actual practice in Japan. If return of spontaneous circulation is not achieved after resuscitation is performed appropriately for ≥10 min, death or severe neurological sequelae are likely; thus, in CoSTR2015, it is considered appropriate to decide whether resuscitation efforts should be continued in such cases after taking the following factors into account on an individual basis: specific conditions before delivery (determination of the timing of injury); the cause of cardiac arrest; gestational age; the appropriateness of the resuscitation performed; the availability of intensive care measures, such as therapeutic hypothermia; the reversibility of the condition; and the parents' thoughts about the anticipated outcomes.

In CoSTR 2020, the following recommendation was proposed, and the time frame for deciding whether to terminate resuscitation efforts was extended from 10 min to 20 min on the premise that all recommended resuscitation procedures were performed beforehand: "Failure to achieve return of spontaneous circulation in newborn infants despite 10 to 20 minutes of intensive resuscitation is associated with a high risk of mortality and a high risk of moderate-to-severe neurodevelopmental impairment among survivors. However, there is no evidence that any specific duration of resuscitation consistently predicts mortality or moderate-to-severe neurodevelopmental impairment. If, despite provision of all the recommended steps of resuscitation and excluding reversible causes, a newborn infant requires ongoing cardiopulmonary resuscitation (CPR) after birth, we suggest discussion of discontinuing resuscitative efforts with the clinical team and family. A reasonable time frame to consider this change in goals of care is around 20 minutes after birth. (Weak recommenda-

**Table. 1** Modified flow diagram of number of studies and infants included for each specified outcome for infants experiencing resuscitation that exceeded 10 minutes.

| |
|---|
| **Systematic Review**<br>15 studies included<br>470 infants |
| **Survival to Discharge**<br>13 studies included, 432 infants<br>176/432 (41%) |
| **Survival to Last Follow-Up**<br>15 studies included*, 470 infants<br>187/470 (40%)<br>*2 studies reported survival to hospital discharge,<br>13 studies reported survival to post-discharge follow-up |
| **Neurodevelopmental Outcome Among Survivors**<br>13 studies included, 277 infants<br>86 infants survived<br>80 infants assessed for neurodevelopment (6 lost to follow-up)<br>50/80 (62.5%): Moderate or severe neuroimpairment<br>30/80 (37.5%): No moderate or severe neuroimpairment |
| **Composite: Survival Without Neurodevelopmental Impairment (NDI)**<br>13 studies included, 277 infants<br>191/277 (69%): Died by last follow-up<br>50/277 (18%): Survived with moderate or severe NDI<br>30/277 (11%): Survived without moderate or severe NDI<br>6/277 (2%): Lost to follow-up |

(ILCOR CoSTR2020)

tion, very low-certainty evidence).". This recommendation is based on a study that examined the developmental outcome in 277 neonates who were cardiac arrest or bradycardia (<60 bpm) for at least 10 min after birth and found an absence of moderate to severe neurodevelopmental disorders in 11% of patients (30) , although death occurred in 69% (191), and moderate to severe neurodevelopmental disorders occurred in 18% (50) (**Table. 1**) [1]. It is most important to complete all steps of resuscitation (last step: intravenous administration of adrenalin). The rationale for the 20-min time frame is that studies suggest that the time taken to accomplish steps of a resuscitation up to the point of administration of 1 or more doses of epinephrine varies widely across studies but may take as long as 20 min [2-5]. However, a Japanese study of neonates whose heart beats were not detected 10 min after birth [6] showed a longer time frame for adrenalin administration than in other countries; the timing of adrenaline administration varied greatly (5-85 min, median of 15 min), and adrenalin was administered >20 min after birth in 9 out of 28 neonates and >30 min after birth.

This finding suggests that the resuscitation environment and standardization of resuscitation procedures in Japan need to be improved. Results were also reported for 39 patients whose heart beats were detected for the first time 20 min after birth or whose heart rates exceeded 100 bpm: 38% (15/39) survived until the final follow-up, and 40% of these patients (6/15) did not have moderate to severe neurological disorders [1]: however, 7 out of 9 surviving neonates with poor developmental prognosis were from Japan, suggesting that the developmental outcome is worse in Japan compared to those in other countries.

According to the "Justification and Evidence-to-Decision Framework Highlights" in CoSTR2020, the following factors must be considered for individual cases when deciding to terminate resuscitation efforts:

- specific conditions before delivery (the timing of perinatal insult), the cause of cardiac arrest, gestational age, and the perceived adequacy of resuscitative interventions,
- post-resuscitative resources, such as neonatal intensive care, and neuroprotective strategies, such as therapeutic hypothermia.
- reversibility of the condition,
- the family's stated preferences and values

Thus, discontinuing resuscitative efforts should be determined according to each clinical conditions.

Chap. 3

## III Education

Since CoSTR2015, it has been proposed that students and professionals who have completed a resuscitation course should undergo retraining at least once a year because repeated training according to individual needs may develop certain behaviors and skills. Specifically, in addition to daily clinical practice, repeated and continuous learning using e-learning materials and the skill training course can contribute to the maintenance and improvement of skills and knowledge for neonatal resuscitation. It is also proposed that neonatal resuscitation instructors should provide objective, structured and timely feedback verbally or in writing. This feedback approach is not specific to these instructors but is common to education and training in general, and it should be integrated into all NCPR courses.

(Takahiro Sugiura)

### Key points

1. When return of spontaneous circulation cannot be achieved, even after adrenaline has been administered and the preceding procedures have been attempted, discuss the possibility of termination of resuscitation with the neonate's family. The time frame for this process is approximately 20 min.
2. This 20-min time frame is based on the fact that, although the time required to complete intravenous adrenaline administration and the preceding procedures varies, it takes at most 20 min.
3. The most important point when considering the termination of resuscitation is to ensure that each recommended resuscitation step is performed properly and to determine whether to continue resuscitation efforts based on various factors specific to the individual case.

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Chapter

# 4

# Better utilization of teamwork in neonatal resuscitation

Chap.4

# Teamwork in neonatal resuscitation

## I Importance of teamwork

Simulation studies have shown that resuscitation requires rapid decision making and the rapid implementation of procedures under psychological pressure, and such complex tasks lead to errors that result in an unfavorable prognosis in neonates [1-9].

For providing high-quality resuscitation, teamwork is an important element that has attracted attention in recent years. It is incontrovertible that all members involved in neonatal resuscitation must have accurate knowledge and solid resuscitation skills, but simply gathering team members will not result in good resuscitation, even if each participating member is highly competent. Cooperation among team members—teamwork—is essential to ensure that the team functions well. This section presents the knowledge related to teamwork.

## II Information sharing

In NCPR2020, a section was added on the provision of briefings to share information before delivery. Sharing information about mothers and infants in advance enables the prediction of risks and effective discussions about whether neonatal resuscitation is required, and if so, who will take on which responsibilities, whether adequate staff are allocated, and whether supplies are sufficient. Thorough predelivery preparation for neonatal resuscitation is extremely important for high-quality resuscitation. If more advanced resuscitation is required, sharing information about how to request help and the available human resources will be important.

# III Anticipating critical events

When resuscitation is likely to be required after delivery, it is extremely important to anticipate possible critical events. Preparing for anticipated events, such as situations requiring ventilation, endotracheal intubation, chest compressions, and medication administration, is crucial for avoiding confusion after resuscitation procedures are initiated. Good team discussions about anticipated events are also useful for smooth resuscitation.



# IV Allocation of roles

Allocation of roles within the team facilitates smooth resuscitation. It is recommended to decide who is the leader, who will implement the procedures, who will provide support, and similar matters. The tasks involved in resuscitation are diverse and include respiratory management, heart rate assessment, time management, chest compressions, and the preparation of instruments. Thus, predetermined roles may change depending on the situation. If predetermined roles need to be changed, the leader must give instructions, or a member must propose the change to the whole team and obtain team agreement.

# V Situational awareness

The condition of neonates after birth is extremely unstable, and they require close observation. The same is true for neonates who are being resuscitated, and it is essential to respond promptly and appropriately to observed changes.

Situational awareness is a state in which each member perceives the ever-changing condition and environment of the patient. A pulse oximeter, an ECG monitor, and similar means that objectively display the neonate's condition play a substantial role in situational awareness. Assessing the maneuvers and decisions made by other team members, making proposals for improvement, and sharing information within the team will greatly facilitate situational awareness.

The maneuvers used in neonatal resuscitation are delicate and complex and require a great deal of concentration. Therefore, the person who performs these maneuvers may not be able to perceive other elements of the neonate's condition and the overall resuscitation situation. Thus, in some cases, verbal communication may be necessary to share the ongoing situation within the team.

## VI Communication

While performing neonatal resuscitation, the whole resuscitation team must be kept informed of what is happening within the team, what each team member is doing, and whether the resuscitation techniques are being performed correctly by team members. It is desirable for the resuscitation team members to feel free to communicate with each other without hesitation. Team members should ensure that the messages that they send are received and understood by the receivers (closed-loop communication) [10]. It is essential that team members function in an environment where they can exchange honest opinions without concerns about authority and seniority and that team members have communication skills.

## VII Leadership

Anyone who has completed neonatal resuscitation training and has full understanding of the NCPR flow can participate in the neonatal resuscitation team as a leader. The leader does not have to be older than others and does not have to be in a senior position. What is required is the leadership to make decisions about resuscitation strategies quickly and appropriately and to give clear instructions to the team. If, by any chance, the leader cannot assess the situation or cannot decide on a strategy, he or she should hand over the leadership without hesitation. It is common for leadership to be handed over to a more experienced or more appropriate person in difficult resuscitation cases.

## VIII Psychological factors and supportive behaviors

Being in a situation in which one's own skills can affect the life of a neonate causes a great deal of psychological stress for the person performing resuscitation. Managing this stress is another important issue to address. In fact, many errors are caused by psychological stress in actual settings of neonatal resuscitation, for example, being unable to introduce ventilation properly despite doing it successfully during practice, being unable to count the heart rate properly during auscultation, and being unable to intubate the trachea properly due to nervousness. To address these errors caused by psychological factors, it is necessary for team members to help and talk to each other. If the procedure does not go well, the leader may decide to change role assignments.

# IX Debriefing

It is extremely important for team members to have a debriefing after neonatal resuscitation. It is highly useful to review and discuss the resuscitation sequences taken, the points that were performed well, and the points that need improvement. In addition to the points that need improvement, the points that were performed well must be reviewed to understand why they were performed well. This step is necessary to validate whether the adequate treatment provided was the result of correct decisions or was coincidental.

(Hagane Shimaoka)

## Key points

1 Good teamwork is essential for high-quality neonatal resuscitation.

2 Information sharing, anticipation of critical events, and preparation for resuscitation are crucial for performing neonatal resuscitation smoothly.

3 Each team member must be aware of the ever-changing situation.

4 It is necessary to be conscious of leadership responsibilities and of the need for mutual help and communication among team members.

5 Team members must communicate actively, help each other with stress management, and compensate for errors due to psychological factors.

6 Having a debriefing after neonatal resuscitation to allow discussion among team members is extremely useful.

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Chap.4

# Need for continuous learning and on-the-job training (OJT) in NCPR

## I Need for continuous learning

### 1 Why is continuous learning necessary?

To prepare for unexpected encounters with neonatal asphyxia, all staff involved in neonatal resuscitation must always maintain necessary skills. Taking a 1- to 2-day resuscitation course every few years to renew qualifications is an effective means of reviewing techniques and maintaining them for the short term, but that alone is not sufficient for maintaining resuscitation skills over the long term [1-2]. Additionally, the acquisition of a qualification after completing a course does not necessarily mean that qualified individuals can perform neonatal resuscitation perfectly. They must have the philosophy (attitude), knowledge, and techniques that enable resuscitation to be performed promptly and appropriately when they encounter a case of neonatal asphyxia. Continuous learning is necessary to perform neonatal resuscitation confidently after completing a course.

### 2 Methods for continuous learning

Training for continuous learning does not have to be as lengthy as accreditation courses. Discussions of questions that come up during routine clinical practice are also a form of continuous learning (informal learning). Combined low-dose, high-frequency training, in which brief trainings on techniques are repeated many times with short simulations of points for improvement, allow training to be provided effectively according to the environment and working situations of individual facilities, Various learning methods are available, such as learning resuscitation techniques that take into account the actual situation and background of the resuscitation site at the learner's own institution (i.e., contextual learning), learning to ensure mastery of NCPR (i.e., mastery learning), and intensive practice to achieve well-considered results (i.e., deliberate practice). [1-2]

## 3 Debriefing and repeated simulation

Debriefings should be held after actual neonatal resuscitation in the clinical settings. The use of simulations to review feedback from real clinical experiences is effective for improving the quality of neonatal resuscitation. Consider taking time for debriefing after a neonatal resuscitation to foster a workplace culture that facilitates the continuous and autonomous learning of neonatal resuscitation methods.

# II Need for on-the-job training (OJT)



With the introduction of sophisticated simulators and technologies, simulation-based training is now able to largely reproduce the real-life resuscitation environment at a realistic level. Nonetheless, simulation is not a universal tool for learning all aspects of neonatal resuscitation. On-the-job training (OJT) in the actual clinical setting is an important training element for health care professionals who hold lives in their hands, and their learning of NCPR comes to fruition when they encounter and successfully resuscitate real patients. There are many things that can be learned by practicing in the actual clinical setting, such as how to perform accurate and high-quality resuscitation under the psychological stress of knowing that one's technique will affect the outcome of the neonate; how to respond to unexpected situations; and how to be considerate of the family. In OJT, the safety of the neonates should be the top priority, but in terms of the learning environment, it is also important to ensure the psychological safety of the staff participating in OJT. Resuscitation instructors need to be aware of the gap between simulation and practice and consider the safety of both the neonate and the learner.

(Hagane Shimaoka)

### Key points

1 Continuous learning is necessary for maintaining neonatal resuscitation techniques.

2 Effective training can be provided according to the environment and situation of individual facilities.

3 Learning neonatal resuscitation through OJT is extremely valuable.

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The Textbook of Neonatal Cardiopulmonary Resuscitation

# Based on the 2020 Guidelines of the Japan Resuscitation Council

Fourth Edition

MEDICAL VIEW