

# Chapter 4

## N CPR; Neonatal Cardiopulmonary Resuscitation

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### ■ 1 Introduction

About 10% of newborns require certain degree of support to start their breathing, and less than 1% needs comprehensive resuscitation (LOE 4<sup>1,2</sup>). In Japan, there are nearly 1.1 million births per year, so more than 0.1 million newborns require some sort of support to stabilize their cardio-respiratory condition at birth.

Moreover, from the national annual statistical data on maternal health in 2008, considering the place of birth in our country, hospital birth consists only 51.1%. Remaining 47.7% are at obstetrician's clinic and 1% at midwifery home so there are many cases of birth without attendance of a pediatrician. Therefore, it is not ideal for us to totally accept the guidelines that are made assuming pediatrician's attendance at every labor in general hospital as in North America. We should construct a guideline that can be applied to births which happens at obstetrician's clinic and midwifery home. In other hands, the person who is in charge of the clinical practice should always strive to establish safer and effective system based

on international standards. Although for procedures that is internationally proven safe and recommended in CoSTR 2010 but that might cause serious complication when applied to Japanese neonates, we withheld the recommendation in Japan unless it is also proven safe in our population. For those procedures, clinical trials of high quality are waited to be done.

In medical terminology, newborns are defined to be infants under 28 days of age. In CoSTR 2010, there are noteworthy differences between pediatrics and newborn CPR. Therefore, it is expected that confusion might arise in the attempt of CPR for infants under one month old at pediatrics ward or pediatrics emergency department. With priority set to avoid the withholding and delay of the CPR procedures arising from adherence to minor differences between pediatrics and newborns, the guideline standing committee by Japan Resuscitation Council and Japanese Foundation of Emergency Medicine has decided to recommend those policies regarding CPR of infants;

- The resuscitation of an infant at delivery room, newborn nursery, and NICU (infant under corrected age of one month) should be done according to guidelines of neonatal resuscitation.
- In the case of the resuscitation of an infant with birth asphyxia by person who are not specialized to neonatal medicine (eg. EMS staff) outside of delivery room, the resuscitation can be started by following the guidelines of pediatrics resuscitation.
- Whether the resuscitation of an infant under 28 days of age in pediatrics ward and pediatrics outpatient clinic be done in accordance to guidelines of neonatal resuscitation or pediatrics resuscitation, should be followed by policies set at each institutes.

## **1. Routine Care**

Newborn infants who are born at term and are breathing or crying and have good tone must be dried and kept warm (Class I). These actions can be provided with the baby lying on the mother's chest and should not require separation of mother and baby (Class IIb).

## **2. Steps for Resuscitation Care**

All others need to be assessed to determine their need for one or more of the following actions in sequence:

- A. Initial steps in stabilization (dry and provide warmth, position, assess the airway, stimulate to breathe)
- B. Ventilation
- C. Chest compressions
- D. Medications or volume expansion

Progression to the next step is initially based on simultaneous assessment of 2 vital characteristics: heart rate and respirations (Class I). Progression occurs only after successful completion of the preceding step. Approximately 30 seconds is allotted to complete each of the first 2 steps successfully, reevaluate, and decide whether to progress to the next (Class IIa) (see Figure: Newborn Resuscitation Algorithm).

**Insert Newborn Resuscitation Algorithm**

### **3. Neonatal Resuscitation Algorithm**

The newly born infants who do not require resuscitation can generally be identified by a rapid assessment of the following 3 characteristics:

- Term gestation?
- Crying or breathing?
- Good muscle tone?

If the answer to all 3 of these questions is “yes,” the baby does not need resuscitation and should not be separated from the mother. The baby should be dried, placed beside the mother, and covered with dry linen to maintain temperature. Observation of breathing, activity, and color should be ongoing. If the answer to any of these assessment questions is “no,” the infant should receive one or more of the following 4 categories of action in sequence:

- A. Initial steps in stabilization (provide warmth, clear airway if necessary, dry, stimulate)

B. Ventilation

C. Chest compressions

D. Administration of epinephrine and/ or volume expansion

Progression to the next step is initially based on simultaneous assessment of 2 vital characteristics: heart rate (whether greater than or less than 100 beats per minute) and respirations (apnea, gasping, or labored or unlabored breathing). Progression occurs only after successful completion of the preceding step. Approximately 30 seconds is allotted to complete each of steps successfully, reevaluate, and decide whether to progress to the next.

The initial steps of resuscitation are to provide warmth by placing the baby under a radiant heat source, positioning the head in a “sniffing” position to open the airway, clearing the airway if necessary with a bulb syringe or suction catheter, drying the baby, and stimulating breathing.

The routine endotracheal suctioning of infants born through meconium-stained amniotic fluid are unnecessary, even when the newborn is depressed.

You should simultaneously evaluate the newborn heart rate and respirations every 30 seconds. Assessment of heart rate should be done by intermittently auscultating the precordial pulse. A pulse oximeter can provide a continuous assessment of the pulse and the state of oxygenation, but the device takes 1 to 2 minutes to apply.

When the baby has spontaneous effective respirations and heart rate above 100 bpm, you evaluate the labored breathing and cyanosis. If the baby has labored breathing and cyanosis, you should use pulse oximeter and may assist the baby’s breathing by CPAP (continuous positive airway pressure) with room air or may give him supplemental oxygen. The probe should be attached to the right upper extremity.

If the infant remains apneic or gasping, or if the heart rate remains less than 100 per minute after administering the initial steps, start positive pressure ventilation with pulse oximeter. Assisted ventilation rates of 40 to 60 breaths per minute are commonly used.

Chest compressions are indicated for a heart rate that is less than 60 per minute despite adequate ventilation for 30 seconds. Compressions and ventilations should be coordinated to avoid simultaneous delivery. There should be a 3:1 ratio of compressions to ventilations with 90 compressions and 30 breaths to achieve approximately 120 events per minute to maximize ventilation at an achievable rate. Compressions should be delivered on the lower third of the sternum to a depth of approximately one third of the anterior-posterior diameter of the chest. Two

techniques have been described, the 2 thumb–encircling hands technique is recommended for performing chest compressions in newly born infants. However, if the heart rate remains less than 60 per minute despite adequate ventilation (usually with endotracheal intubation) with high concentration oxygen and chest compressions, epinephrine is recommended to be administered intravenously. The recommended IV dose is 0.01 to 0.03 mg/kg per dose. While access is being obtained, administration of a higher dose (0.05 to 0.1 mg/kg) through the endotracheal tube may be considered. Volume expansion (isotonic crystalloid solution) should be considered when blood loss is known or suspected (pale skin, poor perfusion, weak pulse) and the baby’s heart rate has not responded adequately to other resuscitative measures. The recommended dose is 10mL/kg. For term infants, air should be used for resuscitation at birth. If oxygenation ideally guided by pulse oximetry remains unacceptable, use of a higher concentration of oxygen should be considered. For preterm infants, blended oxygen and air should be given judiciously and its use guided by pulse oximetry.

#### **4. Discussion Points in 2010 CoSTR**

Since publication of the *2005 International Consensus on CPR and ECC Science With Treatment Recommendations*<sup>3, 4</sup> several controversial neonatal resuscitation issues have been identified. The literature was researched and a consensus was reached on the assessment of oxygenation and role of supplementary oxygen, peripartum management of meconium, ventilation strategies, devices to confirm placement of an advanced airway (eg, tracheal tube or laryngeal mask airway), medications, maintenance of body temperature, postresuscitation management, and considerations for withholding and discontinuing resuscitation. Educational techniques for teaching, assessing, and maintaining resuscitation knowledge and skills and issues regarding the personnel needed at cesarean sections were also debated.

## 5. The Major New Recommendations

Followings are the major new recommendations.

- Progression to the next step following the initial evaluation is now defined by the simultaneous assessment of 2 vital characteristics: heart rate and respirations (Class I).
- Oximetry should be used for evaluation of oxygenation because assessment of color is unreliable (Class I).
- For babies born at term it is best to begin resuscitation with air rather than 100% oxygen (Class I).
- Administration of supplementary oxygen should be regulated by blending oxygen and air, and the concentration delivered should be guided by oximetry (Class IIb).
- The available evidence does not support or refute the routine endotracheal suctioning of infants born through meconium-stained amniotic fluid, even when the newborn is depressed (Class IIb).
- The chest compression-ventilation ratio should remain at 3:1 for neonates unless the arrest is known to be of cardiac etiology (Class I), in which case a higher ratio should be considered (Class IIa).
- Therapeutic hypothermia should be considered for infants born at term or near-term with evolving moderate to severe hypoxic-ischemic encephalopathy, with protocol and follow-up coordinated through a regional perinatal system (Class I).
- It is appropriate to consider discontinuing resuscitation if there has been no detectable heart rate for 10 minutes. Many factors contribute to the decision to continue beyond 10 minutes (Class IIb).

### ▲ Knowledge gaps

2010 CoSTR recommends that Cord clamping should be delayed for at least 1 minute in babies who do not require resuscitation, however strong concerns on possible increase in severe icteric cases following delayed Cord clamping were shown by obstetrics committees, because incidence of jaundice is higher in Japanese newborn babies compared with Caucasian babies. High quality clinical studies to confirm safety of delayed Cord clamping in Japanese newborn babies should be carried out before we accept this recommendation.

## ■ 2 Initial Assessment and Intervention

### 1. Assessment of Cardiorespiratory Transition and Need for Resuscitation

A prompt increase in heart rate remains the most sensitive indicator of resuscitation efficacy (LOE 5<sup>5</sup>). Of clinical assessments, auscultation of the heart rate is the most accurate, with palpation of the umbilical cord less so. However, both are relatively insensitive (LOE 2<sup>6</sup>, LOE 4<sup>7</sup>). Several studies have addressed the accuracy of pulse oximetry in measuring heart rate in the delivery room. However, none of these studies examined the impact of these measurements on the outcomes of resuscitations (LOE 4<sup>7, 8</sup>). Pulse oximetry (SpO<sub>2</sub>) and heart rate can be measured reliably after 90 seconds from birth with pulse oximeter designed to reduce movement artifact and a neonatal probe (LOE 4<sup>9, 10</sup>). Preductal values, obtained from the right wrist or hand are higher than post-ductal values (LOE 5<sup>8, 11</sup>). Applying the oximeter probe to the subject before connecting it to the instruments will produce reliable results more quickly (LOE 4<sup>10</sup>).

There is clear evidence that an increase in oxygenation and improvement in color may take many minutes to achieve, even in uncompromised babies. This has removed color as an indicator of oxygenation or resuscitation efficacy. The oximeter can be used to adjust the oxygenation increase to that of the uncompromised baby born at term.

Heart rate should remain the primary vital sign by which to judge the need for and efficacy of resuscitation (Class I). Auscultation of the precordium should remain the primary means of assessing heart rate (Class I). Palpation of the umbilical pulse

has a high likelihood of underestimating the heart rate, but is preferable to other palpation locations (Class IIb). For babies requiring ongoing resuscitation and/or respiratory support, the pulse oximetry should be used (Class I). The sensor should be placed on the baby's right hand or wrist, where reflect preductal values (Class I). Because of concerns regarding the ability to consistently obtain accurate measurements, pulse oximetry should be used in conjunction with, and not replace, clinical assessment of heart rate during newborn resuscitation (Class I).

## **2. Use of Supplementary Oxygen**

In term infants receiving resuscitation with intermittent positive pressure ventilation, 100% oxygen conferred no advantage over air in the short term and resulted in increased time to first breath and /or cry (LOE 2<sup>12, 13</sup>). Meta-analyses of these showed a decrease in mortality with group where resuscitation was initiated with air<sup>14, 15</sup>.

There is evidence in newborn animal models of asphyxia that exposure to high concentrations of oxygen at resuscitation does not confer any clinical advantage and is potential harmful at the cellular level<sup>16, 17</sup>. Two animal models of hypoxia/ischemia and persistent bradycardia found that those resuscitated with room air as opposed to 100% oxygen developed untoward biochemical change in the brain (LOE 5<sup>18, 19</sup>).

In preterm infants <32 weeks, if attempting to mimic the gradual rise in oxygen saturation of healthy term babies in the first 10 minutes after birth by titrating the concentration to the baby's saturation, initial use of air or 100% oxygen is more likely to result in hypoxemia or hyperoxemia respectively that does initiating resuscitation with 30% or 90% and titrating the oxygen saturation (LOE 2<sup>11, 20</sup>). There is insufficient evidence in babies born at 32-37 weeks gestation to define the appropriate oxygen administration strategy.

In term infants receiving resuscitation at birth with positive pressure ventilation, it is best to begin with air as opposed to 100% oxygen (Class I). If, despite effective ventilation there is no increase in heart rate or oxygenation, which is guided by oximetry, remains unacceptable, use of a higher concentration of oxygen should be considered (Class I). As many preterm babies less than 32 weeks gestation will not reach target saturations in air, blended oxygen and air may be given judiciously and ideally guided by pulse oximetry (Class IIb). Both hyperoxemia and hypoxemia should be avoided (Class I). If a blend of oxygen and air is not available, resuscitation should be initiated with air (Class IIb).



### ▲ Knowledge gaps

- Further study associated with physiological change of oxygen saturation after birth is needed to decide the target saturation in both term and preterm babies.
- Further study is needed to decide the best initial oxygen concentration for preterm babies.

## ■ 3 Peripartum Suctioning

Peripartum suctioning was examined from 2 perspectives: (1) suctioning of the airway in depressed neonates born through clear amniotic fluid and (2) tracheal suctioning in depressed neonates born through meconium stained amniotic fluid.

### 1. Suctioning of the Upper Airway

There is no evidence to support or refute suctioning of the mouth and nose of depressed neonates at birth when the infant is born through clear amniotic fluid. In healthy neonates suctioning of mouth and nose is associated with cardio-respiratory complications (LOE 1<sup>21, 22</sup>). In intubated, sedated, and/or paralyzed infants post resuscitation, endotracheal suctioning in the absence of secretions may result in a decrease in oxygenation, increased cerebral blood flow and intracranial pressure, and decrease in compliance (LOE 5<sup>23</sup>).

Routine intrapartum oropharyngeal and nasopharyngeal suctioning for infants born with clear and/or meconium-stained amniotic fluid (MSAF) is no longer recommended (Class III).

### 2. Tracheal Suctioning with Meconium Stained Amniotic Fluid

Depressed infants born to mothers with MSAF are at increased risk to develop meconium aspiration syndrome (MAS) (LOE 4<sup>24, 25</sup>). Although use of tracheal suctioning has not been associated with reduction in the incidence of MAS or mortality in these infants (LOE 4<sup>26</sup>, LOE 5<sup>27</sup>). There are no randomized controlled studies that have compared intubation and tracheal suctioning and no tracheal suctioning in depressed infants.

The available evidence does not support or refute the routine endotracheal suctioning of depressed infants born through meconium stained amniotic fluid (Class IIb).

## ■3 Ventilation Strategy

Ventilation strategy was examined from 4 perspectives (points of view).

- (1) The characteristics of the initial assisted breaths and PEEP
- (2) CPAP during or following resuscitation
- (3) Device to assist ventilation
- (4) Strategy in a condition where there are limited medical devices

### 1. Initial Breaths (Ventilation)

Both longer and shorter inspiratory times are in clinical use for initial ventilation in term infants, but there are no RCTs comparing these 2 patterns. In a few cases in term infants, a prolonged initial inflation of 5 seconds produced a 2-fold increase in functional residual capacity compared with historic controls (LOE 4<sup>28</sup>). A single RCT in resuscitating preterm infants of a 10-second sustained inflation followed by n-CPAP compared with face mask ventilation demonstrated decreased need for intubation in the first 72hrs, shorter duration of ventilatory support, and reduced BPD (LOE 1<sup>29</sup>). Two other RCTs failed to show a benefit of a sustained initial inflation followed by n-CPAP in delivery room (LOE 1<sup>30, 31</sup>). Multiple variables among the 3 RCTs, such as mode of ventilation (nasopharyngeal tube versus face mask, T-piece versus self-inflating bag), and the use of CPAP in the delivery room make it difficult to decide whether initial sustained inflation for establishing a functional residual capacity in VLBWI is effective or not.

IPPV is effective for establishing initial lung expansion in ever apneic VLBWI (Class I).

### 2. Pressure

There is no evidence to support the use of inflation pressures higher than needed for improvement in heart rate or chest expansion. These can usually be achieved in term infants with an inflation pressure of 30 cmH<sub>2</sub>O (LOE 4<sup>28, 32</sup>) and in preterm infants with pressures of 20 to 25 cmH<sub>2</sub>O (LOE 4<sup>33</sup>), but occasionally higher pressures are required (LOE 4<sup>34</sup>). In immature animals at birth, even for a few minutes, ventilation with high tidal volumes and high peak inflation pressures causes lung injury, impaired gas exchange, and reduced lung compliances.

With monitoring, adequate pressures may be about 20cmH<sub>2</sub>O for initial inflation in most preterm infants. 30 to 40 cmH<sub>2</sub>O may be needed in term infants (Class IIa). Without monitoring, providers should start to support breaths with minimum

pressures for establishing heart rate beating faster and must not inflate chest more than needed during supporting breaths in preterm infants at birth (Class I). Higher pressures may be needed for effective ventilation when any prompt improvement in heart rate or chest movement cannot be seen (Class IIa).

### **3. Positive End-Expiratory Pressure (PEEP)**

There is no evidence to support or refute the value of PEEP during resuscitation of term infants. In preterm infants 1 small study did not show a benefit from PEEP during initial stabilization in reducing the number of infants who required intubation in the delivery room (LOE 1<sup>35</sup>). In studies of immature animals in need of intubation, the use of PEEP during initial stabilization after birth improved functional residual capacity, oxygenation, and lung compliance and reduced lung injury (LOE 5<sup>36, 37</sup>), but high level PEEP of 8-12cmH<sub>2</sub>O may reduce pulmonary blood flow and increase the risk of pneumothorax (LOE 5<sup>38, 39</sup>).

PEEP is likely to be beneficial during initial stabilization of apneic preterm infants who require positive-pressure ventilation and should be used if suitable equipment is available (Class IIa).

### **4. Continuous Positive Airway Pressure (CPAP)**

For spontaneously breathing preterm infants at  $\geq 25$  weeks' gestation who have signs of respiratory distress, there is no significant difference between starting CPAP or intubation and mechanical ventilation in the delivery room when considering death or oxygen requirement at 36 weeks postmenstrual age. Compared with intubation, CPAP reduced the rate of mechanical ventilation from 100% to 46% and surfactant use from 77% to 38% in spontaneously breathing infants at 25 to 28 weeks' gestation (LOE 1<sup>40</sup>). In the same trial infants on CPAP had a significantly increased rate of pneumothorax (9% to 3%) (LOE 1<sup>40</sup>). There is no evidence to support or refute the use of CPAP in the term baby.

For very preterm infants, a multifaceted intervention, including PEEP, giving a sustained inflation and starting CPAP in delivery room reduces the need for intubation and rate of mechanical ventilation within 72 hours and reduces incidence of bronchopulmonary dysplasia compared with positive-pressure ventilation with a self-inflating bag via a face mask (LOE 1<sup>29</sup>). When compared with historic controls, use of CPAP for very preterm infants in the delivery room was associated with a decrease in the requirement for intubation, days on mechanical ventilation, and use of postnatal steroids (LOE 4<sup>33</sup>), although a small underpowered

feasibility trial of CPAP/PEEP in delivery room versus no CPAP/PEEP did not show a significant difference in immediate outcomes (LOE 1<sup>35</sup>).

Spontaneously breathing preterm infants who have respiratory distress may be supported with CPAP or intubation and mechanical ventilation. The most appropriate choice may be guided by local expertise and preferences (Class IIa).

### **5. Assisted Ventilation Devices**

There are no clinical studies to support or refute the superiority of the T-piece resuscitator over bag-mask ventilation in newborns requiring positive pressure during resuscitation. In mechanical models target inflation pressures are delivered more consistently when using T-piece resuscitators than with self-inflating bags or flow-inflating bags (LOE 5<sup>41, 42</sup>). In the same model PEEP is maintained more consistently with T-piece resuscitators compared with self-inflating bags or flow-inflating bags (LOE 5<sup>43</sup>), and the ability to deliver a sustained inflation is better with either T-piece resuscitator or flow-inflating bag than with a self-inflating bag (LOE 5<sup>41, 44</sup>).

Ventilation on the newborn can be performed effectively with a flow-inflating bag, a self-inflating bag, or a pressure-limited T-piece resuscitator (Class IIa).

### **6. Laryngeal Mask Airway**

In 1 RCT (LOE 1<sup>45</sup>) providers had similar success providing effective ventilation with either the laryngeal mask airway or face mask among newborns in the delivery room. In 1 retrospective cohort study (LOE 2<sup>46</sup>) and 3 large case series effective ventilation was achieved quickly using a laryngeal mask airway in newborns weighing >2000 g or delivered at  $\geq 34$  weeks' gestation. In 1 RCT (LOE 1<sup>47</sup>) and 1 retrospective cohort study (LOE 2<sup>48</sup>) providers had similar success providing effective ventilation using either the laryngeal mask airway or endotracheal tube among newborns in the delivery room. Although a single cohort study (LOE 2<sup>48</sup>) suggests that newborns resuscitated with a laryngeal mask may require less respiratory support after initial resuscitation, this conclusion is subject to significant selection bias. In multiple small case reports effective ventilation were achieved with a laryngeal mask airway when both face mask ventilation and endotracheal intubation were unsuccessful. There is limited evidence to evaluate the effectiveness of the laryngeal mask airway for newborns weighing <2000 g, delivered at <34 weeks' gestation, in the setting of meconium-stained amniotic fluid, during chest compression, or for administration of emergency intratracheal

medications.

The laryngeal mask airway should be considered during resuscitation of the newborn if face mask ventilation is unsuccessful and tracheal intubation is unsuccessful or not feasible. The laryngeal mask airway may be considered as an alternative to a face mask for positive-pressure ventilation among newborns weighing >2000 g or delivered at  $\geq 34$  weeks' gestation. There is limited evidence, however, to evaluate its use for newborns weighing <2000 g or delivered at <34 weeks' gestation. The laryngeal mask airway may be considered as an alternative to endotracheal intubation as a secondary airway for resuscitation among newborns weighing >2000 g or delivered at  $\geq 34$  weeks' gestation (Class IIa).

#### **▲ Knowledge gaps**

The laryngeal mask airway has not been evaluated in the setting of meconium-stained amniotic fluid, during chest compression, or for administration of emergency intratracheal medications.

### **7. Upper Airway Interface Devices**

Within classes of interfaces, reports conflict about the ability to maintain a seal with an anatomically shaped mask compared with soft round mask (LOE 5<sup>49, 50</sup>). Delivery of positive pressure ventilation via nasal prong has been shown to be superior to delivery via a triangular face mask for outcomes of chest compressions and intubation (LOE 2<sup>51</sup>). It is likely that differences in clinical outcomes that have been reported in several studies may be attributable to the targeted intervention (ie, CPAP versus intermittent positive-pressure ventilation) rather than the interface. Nasal prongs may be a more effective device than face masks for providing respiratory support after birth (LOE 2<sup>51</sup>). There is insufficient evidence to support or refute the use of one type of mask over another for achieving clinical outcome. Nasal prongs are an alternative way of giving respiratory support. Whichever interface is used, providers should ensure that they are skilled in using the interface devices available at the institution. Different masks must be held in different ways to appropriately reduce leak (Class I).

### **8. Exhaled Air Ventilation**

Mouth-to-mouth ventilation is less effective than a self-inflating bag or tube and mask in improving survival rates in newborns with birth asphyxia (LOE 3<sup>52</sup>). Use of mouth-to-mask ventilation at 30 insufflations per minute is as effective as

self-inflating bag-mask ventilation in increasing heart rate in the first 5 minutes after birth (LOE 2<sup>53</sup>). Mask-to-tube ventilation may cause infection in newborn infants (LOE 5<sup>54</sup>). Two studies (LOE 5<sup>55, 56</sup>) demonstrated that tube-to-mask ventilation can be easily taught and acceptable breaths delivered. However, tube-to-mask ventilation was more difficult to use (LOE 5<sup>57</sup>, LOE 3<sup>52</sup>).

Bag-mask ventilation is preferable to mouth-to-mask ventilation or tube-to-mask ventilation during neonatal resuscitation, but one of the latter two should be used when bag-mask devices are not available (Class I). Mouth-to-mask and mouth tube-to-mask ventilation are more difficult to maintain constant pressure and more tiring than bag-mask ventilation for the newborn at birth. Precautions must be taken because these two ventilations may be associated with increased risk of infection in the infant and healthcare provider (Class I).

## **■4 Monitoring During and After Intubation**

### **1. Gas Monitoring Devices**

#### **1) Measurement of Tidal Volume**

There are no studies that compare clinical outcomes with or without monitoring of tidal volume in newborns after resuscitation. In preterm animal models the tidal volume used during initial ventilation after birth may alter subsequent lung function and induce inflammation, but other factors, including the use and level of PEEP, appear to interact with tidal volume in determining specific effects (LOE 5<sup>58, 59</sup>). It is unclear whether the absolute tidal volumes used affected outcomes. Studies in manikins and animals (LOE 5<sup>60, 61</sup>) suggest that providers cannot maintain constant pressures or assess delivered volume during manual ventilation. The position of the mask and degree of leak may be improved by the use of a volume monitor (LOE 5<sup>62</sup>).

Ventilation during newborn resuscitation should aim to adequately inflate the lung while avoiding overinflation (Class I). There is insufficient evidence to recommend routine use of tidal volume monitoring in neonates receiving positive-pressure ventilation during resuscitation (Class IIb).

#### **2) Use of Exhaled CO<sub>2</sub> Detectors to Confirm Tracheal Tube Placement**

Studies (LOE 2<sup>63-65</sup>) suggest that detection of exhaled CO<sub>2</sub> confirms tracheal intubation in neonates with cardiac output more rapidly and accurately than clinical assessment alone. False-negative readings have been reported during

cardiac arrest (LOE 4<sup>66</sup>) despite models suggesting efficacy (LOE 5<sup>67</sup>). False-positive readings may occur with colorimetric devices contaminated with epinephrine (adrenaline), surfactant, and atropine (LOE 5<sup>68</sup>). Neonatal studies have excluded infants who need extensive resuscitation. There is no comparative information to recommend any one method for detection of exhaled CO<sub>2</sub> in the neonatal population. Detection of exhaled CO<sub>2</sub> in addition to clinical assessment is recommended as the most reliable method to confirm endotracheal placement in neonates with spontaneous circulation (Class I).

### **3) Colorimetric CO<sub>2</sub> Detection to Assess Ventilation in Nonintubated Patients**

The use of colorimetric exhaled CO<sub>2</sub> detectors during face mask ventilation of small numbers of preterm infants in the intensive care unit (LOE 4<sup>69</sup>) and the delivery room (LOE 4<sup>70</sup>) has been reported and may help identify airway obstruction. It is unclear whether the use of exhaled CO<sub>2</sub> detectors during face mask ventilation confers additional benefit over clinical assessment alone. No risks attributed to the use of exhaled CO<sub>2</sub> detectors have been identified. The use of exhaled CO<sub>2</sub> detectors with other interfaces (eg, nasal airways, laryngeal masks) during positive-pressure ventilation in the delivery room has not been reported.

There is insufficient evidence to recommend routine use of colorimetric exhaled CO<sub>2</sub> detectors during mask ventilation of newborns in the delivery room (Class IIb).

## **■5 Circulatory Support**

### **1. Chest Compressions**

#### **1) Compression–Ventilation Ratio**

In animal studies of asphyxial models of cardiac arrest, piglets resuscitated with a combination of chest compressions and ventilations had better outcomes than those resuscitated with ventilations or compressions alone (LOE 5<sup>71, 72</sup>). A further study in piglets suggested that sustained chest compressions had a deleterious effect on myocardial and cerebral perfusion, especially during prolonged resuscitation (LOE 5<sup>73</sup>). A physiologic mathematical modeling study suggested that using higher compression-ventilation ratios would result in underventilation of asphyxiated

infants (LOE 5<sup>74</sup>). The model predicts that between 3 and 5 compressions to 1 ventilation should be most efficient for newborns. Manikin studies confirm that the 3:1 compression-ventilation ratio provides more ventilations per minute when compared with higher ratios, but the resuscitation is perceived as being more physically taxing, especially when performed by a lone rescuer (LOE 5<sup>75, 76</sup>). Adult manikin studies using 2 rescuers have shown that a 5:1 ratio provides better-quality chest compressions than a 15:2 ratio (LOE 5<sup>77</sup>) but can result in more missed ventilations per cycle (LOE 5<sup>78</sup>). A pediatric manikin study of mouth-to-mouth ventilation by a lone lay rescuer found equivalent minute ventilation for both the 15:2 and 5:1 ratios, but the 15:2 ratio produced more chest compressions per minute (LOE 5<sup>79</sup>). With 2-rescuer CPR provided by nursing students, however, minute ventilation and compressions per minute were increased with the 5:1 ratio compared with the 10:2 and 15:2 ratios (LOE 5<sup>80</sup>). When the 15:2 ratio was compared with the 30:2 ratio in a 1-rescuer model of medical personnel using adolescent, child, and infant manikins, more compression cycles could be achieved with the 30:2 ratio on all manikins with no apparent effect on quality of compressions (LOE 5<sup>81</sup>). Effect on ventilation, however, was not assessed. One study in children suggested that CPR with rescue breathing is preferable to CPR alone when the arrest is of noncardiac etiology (LOE 5<sup>82</sup>). There are no data regarding the optimum compression-ventilation ratios in neonates or neonatal models of primary cardiac versus predominantly asphyxial arrest.

## **2) The 2 Thumb–Encircling Hand Technique and the 2-finger Technique of Chest Compressions**



Evidence from randomized studies in swine models (LOE 5<sup>83, 84</sup>), manikin studies (LOE 5<sup>81, 85</sup>), small case series (LOE 4<sup>85</sup>), and cadavers (LOE 5<sup>86</sup>) support the current practice of favoring the 2 thumb–encircling hands technique of chest compressions when compared with the 2-finger technique. The former method produces higher blood pressure, can sustain a consistent quality of compressions for a longer time, and is perceived as easier and less tiring for the provider. One manikin study involving a variety of medical or quasimedical personnel found no difference in a number of qualitative measures between the 2 techniques other than significantly fewer compressions were judged as too shallow with the 2-thumb technique. One small case series in newborns found higher systolic blood pressure generated with the 2-finger technique when compared with the 2 thumb–encircling hands technique (LOE 4<sup>87</sup>). Both techniques, however, generated comparable and adequate diastolic pressures, a more important determinant of coronary perfusion. Chest compressions in the newborn should be delivered by the 2 thumb–encircling hands method as the preferred option (Class IIa).

### **3) Chest Compression Part and Depth**

Compressions should be centered over the lower third of the sternum rather than the mid-sternum (LOE 5<sup>88, 89</sup>). Chest compression depth should favor one third the external anterior-posterior diameter of the chest rather than deeper compressions (LOE 5<sup>90</sup>).

There is no evidence from quality human, animal, manikin, or mathematical modeling studies to warrant a change from the current compression-ventilation ratio of 3:1. Strategies should be considered for optimizing the quality of

compressions and ventilations with as few interruptions as possible (Class IIa).

Because ventilation is critical to reversal of newborn asphyxial arrest, any higher ratio that decreases minute ventilation should be introduced with caution. If the arrest is known to be of cardiac etiology, a higher compression-ventilation ratio should be considered (eg, 15:2) (Class IIa).

Compressions should be centered over the lower third of the sternum and should compress the chest one third the anterior-posterior diameter. Any chest compressions should be performed in combination with adequate inflation breaths (Class I).

### **▲ Knowledge gaps**

There is insufficient evidence to recommend the chest compression method of newborns by a lone rescuer in the delivery room.

## **2. Medications and Fluid Administration**

### **1) Epinephrine**

Despite the widespread use of epinephrine during resuscitation, no controlled clinical trials have directly compared endotracheal and intravenous administration of epinephrine among neonates with a heart rate < 60 bpm despite adequate ventilation and chest compressions.

Limited evidence from neonatal case series or case reports (LOE 4<sup>91, 92</sup>) indicates that epinephrine administered by the endotracheal route using a wide range of doses (0.003 mg/kg to 0.25mg/kg) may result in return of spontaneous circulation (ROSC) or an increase in heart rate when intravenous access is not available. These case series are limited by inconsistent standards for epinephrine administration and are subject to both selection and reporting bias.

Evidence from one case series utilizing rigorously defined standards for epinephrine administration and outcomes reporting indicates that endotracheal epinephrine (0.01 mg/kg) is likely to be less effective than the same dose administered intravenously (LOE 4<sup>2</sup>). This is consistent with evidence extrapolated from neonatal

animal models indicating that higher doses (0.05 mg/kg to 0.1 mg/kg) of endotracheal epinephrine may be required to achieve increased blood epinephrine concentrations and a hemodynamic response equivalent to intravenous administration (LOE 5<sup>93, 94</sup>). Evidence extrapolated from adult animal models indicates that blood concentrations of epinephrine are significantly lower following endotracheal administration (LOE 5<sup>95, 96</sup>) and endotracheal doses ranging from 0.05 mg/kg to 0.1 mg/kg may be required to achieve ROSC (LOE 5<sup>97</sup>). Although it has been widely that epinephrine can be administered faster by the endotracheal route than by the intravenous route, no clinical trials have evaluated this hypothesis. Two studies have reported cases of inappropriate early use of endotracheal epinephrine before airway and breathing are established (LOE 4<sup>91, 92</sup>).

One case series describing in-hospital pediatric cardiac arrests suggested that survival was higher among infants who received their first dose of epinephrine by the endotracheal route, however the time required for first dose administration using the endotracheal and intravenous routes were not provided (LOE 5<sup>98</sup>). Despite the widespread use of epinephrine during resuscitation, no controlled clinical trials have evaluated the ideal dose of epinephrine among neonates with a heart rate < 60 bpm despite adequate ventilation and chest compressions. Evidence extrapolated from pediatric studies that include infants < 1 year of age (LOE 5<sup>99, 100</sup>) indicate no benefit from intravenous epinephrine doses  $\geq 0.03$  mg/kg. This is in contrast to a single pediatric case series using historic controls that indicated a marked improvement in ROSC using high dose intravenous epinephrine (0.1mg/kg) among children who had not responded to two doses of standard epinephrine (0.01mg/kg) (LOE 5<sup>101</sup>). Further extrapolative evidence from a meta-analysis of 5 adult clinical trials indicates that high dose intravenous epinephrine may increase ROSC, however, it offers no benefit in survival to hospital discharge (LOE 5<sup>102</sup>). Evidence from a planned secondary analysis of a pediatric randomized controlled trial suggests an increased risk of mortality among children receiving high dose intravenous epinephrine (0.1 mg/kg) (LOE 5<sup>99</sup>). Additional evidence from 2 pediatric animal studies (LOE 5<sup>103, 104</sup>) indicated that intravenous epinephrine  $\geq 0.1$  mg/kg increased the risk of post-resuscitation mortality, interfered with cerebral cortical blood flow, and interfered with cardiac output.

There are no published studies comparing standard and high dose endotracheal epinephrine in the neonatal population with hypoxic-hypercarbic arrest and the ideal dose for endotracheal administration is unknown. Data from neonatal case series and animal models suggest that higher doses (0.05 mg/kg to 0.1 mg/kg) of

endotracheal epinephrine may be required to achieve increased blood epinephrine concentrations and a hemodynamic response equivalent to intravenous administration (LOE 4<sup>2, 91</sup>).

If adequate ventilation and chest compressions have failed to increase the heart rate to > 60 beats per minute, then it is reasonable to use epinephrine, despite the lack of human neonatal data (Class IIa). If epinephrine is indicated, a dose of 0.01 to 0.03 mg/kg should be administered intravenously as soon as possible (Class I).

If adequate ventilation and chest compressions have failed to increase the heart rate to > 60 beats per minute and intravenous access is not available, then it is reasonable to administer endotracheal epinephrine (Class IIa). If epinephrine is administered by the endotracheal route, it is likely that a larger dose (0.05 mg/kg to 0.1 mg/kg) will be required to achieve a similar effect to the 0.01 mg/kg intravenous dose (Class IIa). Higher intravenous doses cannot be recommended and may be harmful (Class III).

## **2) Volume Expansion**

Multiple case series support the use of volume expansion in babies with a history of blood loss, including some unresponsive to chest compressions (LOE 4<sup>105</sup>).

Many with pallor and tachycardia responded to volume expansion without having received chest compressions. In the absence of a history of blood loss, there is limited evidence of benefit from administration of volume during resuscitation unresponsive to chest compressions/epinephrine (LOE 4<sup>106</sup>) and some suggestion of potential harm from animal studies (LOE 5<sup>107, 108</sup>).

Early volume replacement with crystalloid or red cells is indicated for babies with blood loss who are not responding to resuscitation (Class D). There is insufficient evidence to support the routine use of volume administration in the infant with no blood loss who is refractory to ventilation, chest compressions, and epinephrine (Class III). Since blood loss may be occult, a trial of volume administration may be considered in babies not responding to resuscitation (Class IIb).

## **3) Naloxone**

Very rarely, a narcotic antagonist (naloxone), sodium bicarbonate (NRP-021), or vasopressors may be useful after resuscitation. There are no data comparing naloxone versus positive pressure ventilation as the main intervention for opioid exposed newborn infants who are apneic at birth. For newborns who are vigorous in the delivery room despite maternal opioids, naloxone increases ventilation

parameters (such as increased alveolar ventilation and improved CO<sub>2</sub> response curves) for a short period of time but the clinical relevance of these observations is questionable (LOE 4<sup>109</sup>). Several other studies found no difference between vigorous naloxone treated and placebo or no drug treated newborns with outcomes of pH, PCO<sub>2</sub>, Apgar scores, and neurologic outcomes (LOE 5<sup>110</sup>). Studies examining the use of naloxone have consistently demonstrated that it is frequently misused (LOE 4<sup>111</sup>). Naloxone given to a baby born to an opioid-addicted mother has been associated with seizures (LOE 5<sup>112</sup>). There are concerns about short and long term safety of naloxone in neonates (LOE 5<sup>113</sup>). Naloxone is absorbed more effectively when given intravenously, but has a shorter half-life compared to intramuscular administration.

Naloxone is not recommended as part of the initial resuscitation for newborns with respiratory depression in the delivery room (Class III). For the clinical situation of a newborn with respiratory depression after maternal opiate exposure the focus needs to remain on effective ventilation and airway support for the persistently apneic newborn (Class I).

#### **4) Vascular access**

Multiple clinical series and case reports suggest that the intraosseous route can successfully deliver fluids and medications during resuscitation of neonates when equipment or personnel skilled in establishing venous access are not available or if other vascular access sites (especially intravenous) cannot be successfully established within several minutes (LOE 4<sup>114, 115</sup>).

Temporary intraosseous access to provide fluids and medications to resuscitate critically ill neonates may be indicated following unsuccessful attempts to establish intravenous vascular access or when caregivers are more skilled at securing intraosseous access (Class IIb).

## **■6 Maintenance of Body Temperature**

A large body of evidence supports the wrapping of newborn infants of 28 weeks' gestation in polythene wraps or bags at birth to reduce heat loss (LOE 116, 117). Some of these infants were hyperthermic on admission to the neonatal intensive care unit, but it is unclear whether this is because they were born hot or because they became overheated during stabilization and transfer. In the absence of polythene wrapping, use of exothermic mattresses maintained the temperature of newborn infants

weighing 1500 g within the normal range (LOE 2<sup>118</sup>). A combination of exothermic mattresses and polythene wrapping during resuscitation is the most effective strategy to avoid hypothermia but may increase the risk of hyperthermia (LOE 3<sup>119</sup>). Delivery room temperatures of at least 26°C for newborns at 28 weeks' gestation in combination with polythene wraps or bags maintained temperatures most effectively (LOE 4<sup>120</sup>, LOE 3<sup>121</sup>).

It is beneficial for newborn infants of < 28 weeks' gestation to be completely covered in a polythene wrap or bag up to their necks after birth and then placed under a radiant heater and resuscitated or stabilized in a standard fashion (Class D). Infants should be kept wrapped until admission and temperature check. Hyperthermia should be avoided (Class D). It is reasonable to keep delivery room temperatures at least 26°C for infants of 28 weeks' gestation (Class IIa).

#### ▲ Knowledge gaps

The available evidence does not support or refute the routine drying of infants before wrapping them in polyethylene wraps or bags at birth.

## ■ 7 Postresuscitation Management

### 1. Temperature

#### 1) Hyperthermia

Infant born to febrile mothers have been reported to have a higher incidence of perinatal respiratory depression, neonatal seizures, cerebral palsy and risk of mortality (LOE 4<sup>122, 123</sup>). There is no evidence to determine whether it is the fever or the cause that increases risk to the baby. In one study, neonatal fever at birth resolved spontaneously within 60 minutes (LOE 4<sup>124</sup>). Adult animal trials show decreases CNS injury with antipyretic therapy to the hyperthermic animals (LOE 5<sup>125</sup>). In randomized study high dose corticosteroids lowered maternal temperature but was associated with an increased number of cases of asymptomatic bacteremia in neonates (LOE 2<sup>126</sup>).

There is insufficient evidence to support or refute the routine use of interventions to lower maternal fever in order to reduce neonatal morbidity and mortality (Class IIb). There should be an increased awareness that the presence of maternal hyperthermia may lead to need for neonatal resuscitation (Class D). The goal is to achieve normothermia and avoid iatrogenic hyperthermia (Class D).

## **2) Therapeutic Hypothermia**

A large body of evidence from 3 large randomized studies (LOE 1<sup>127-129</sup>) and 2 small randomized trials (LOE 1<sup>130, 131</sup>) demonstrated that induced hypothermia (33.5° to 34.5°C) implemented within 6 hours of birth in term infants at highest risk for brain injury (as defined by specific protocols) and with further treatment in neonatal intensive care units is associated with significantly fewer deaths and less neurodevelopmental disability at 18-month follow-up. Both cooling methods (systemic versus selective head cooling) were shown to be effective, but none of the studies compared them directly. A randomized trial (LOE 5<sup>132</sup>) produced remarkably consistent results despite using different methods of cooling.

Newly born infants born at or near-term with evolving moderate to severe hypoxic-ischemic encephalopathy should be offered therapeutic hypothermia (Class D). Whole body cooling and selective head cooling are both appropriate strategies. Cooling should be initiated and conducted under clearly defined protocols with treatment in neonatal intensive care facilities and with the capability for multidisciplinary care (Class D). Treatment should be consistent with the protocols used in the randomized clinical trials (ie, begin within 6 hours of birth, continue for 72 hours after birth, and rewarm over at least 4 hours) (Class D). Carefully monitor for known adverse effects of cooling, eg, thrombocytopenia and hypotension. All treated infants should be followed up longitudinally (Class D).

## **2. Glucose Control**

Newborns with lower blood glucose levels have a higher incidence of brain injury and adverse outcomes after a hypoxic ischemic insult, although no specific level associated with worse outcome has been identified (LOE 4<sup>133</sup>, LOE 3<sup>134</sup>). Increased glucose levels after hypoxia-ischemia do not appear to have adverse effects in studies of pediatric patients (LOE 5<sup>135</sup>) or in animal studies (LOE 5<sup>136</sup>) and may be protective (LOE 5<sup>137</sup>). However, no randomized controlled trials have examined this question. Due to the paucity of data, no specific target glucose concentration range can be identified at present.

Infants who require significant resuscitation should be monitored and treated to maintain glucose in the normal range (Class IIa).

## **▲ Knowledge gaps**

The range of blood glucose concentration that is associated with the least brain injury following asphyxia and resuscitation cannot be defined based on available evidence.

### **3. Timing of Cord Clamping**

For the uncomplicated birth at term there is evidence of a benefit to delaying cord clamping for a minimum time ranging from 1 minute until the cord stops pulsating after delivery. Those with delayed clamping had improved iron status through early infancy but were more likely to receive phototherapy (LOE 1<sup>138</sup>). For an otherwise uncomplicated preterm birth, there is evidence of a benefit to delaying cord clamping for a minimum time ranging from 30 seconds to 3 minutes after delivery. Those who experienced delayed clamping in this group had higher blood pressures during stabilization and a lower incidence of intraventricular hemorrhage (LOE 1<sup>139</sup>) and received fewer blood transfusions but were more likely to receive phototherapy (LOE 1<sup>138</sup>). There are limited data on the hazards or benefits of delayed cord clamping in the nonvigorous infants<sup>140, 141</sup>.

ILCOR 2010 CoSTR recommend delay in umbilical cord clamping for at least 1 minute for newborn infants not requiring resuscitation. However, transcutaneous bilirubin values in Japanese infants were significantly higher over a longer period compared with Caucasian infants. (J-LOE 4<sup>142</sup>). Because the high frequency of mutation of the bilirubin uridine diphosphate-glucuronosyltransferase gene is associated with high incidence of neonatal hyperbilirubinemia in Japanese babies (J-LOE 3<sup>143, 144</sup>). If delay in cord clamping is introduced in Japan, increasing risk of phototherapy and longer hospitalization are of special concern. So delay in umbilical cord clamping will be held for further consideration in Japan. There is insufficient evidence to support or refute a recommendation to delay in cord clamping in Japanese babies (Class IIb).

#### **▲ Knowledge gaps**

There is a need for further research in this area to clear these problems before introduction of delayed cord clamping.

## **■8 Withholding or Discontinuing Resuscitative Efforts**

### **1. Non-Initiation of Resuscitation**



Mortality and morbidity for newborns varies according to region and availability of resources (LOE 4<sup>145</sup>). Social science studies indicate that parents would like a larger role in decisions to start resuscitation and continue life support of severely compromised newborns. Opinions among neonatal providers vary widely regarding the benefits and disadvantages of aggressive therapies in such newborns (LOE 4<sup>146, 147</sup>). Some data are available to help identify conditions associated with high mortality and poor outcome (LOE 4<sup>148, 149</sup>). Such conditions may include extreme prematurity and infants with anomalies that predict extreme morbidity or early death. Treatment and outcome of infants at the margins of viability may be influenced by factors in addition to gestational age and birthweight<sup>150</sup>. Non-initiation of resuscitation and withdrawal of cardiorespiratory support are ethically equivalent<sup>151</sup>.

When gestation, birth weight, or congenital anomalies are associated with almost certain early death and an unacceptably high morbidity is likely among the rare survivors, resuscitation is not indicated. In conditions associated with a high rate of survival and acceptable morbidity, resuscitation is nearly always indicated. In conditions associated with uncertain prognosis, when there is borderline survival and a relatively high rate of morbidity, and where the burden to the child is high, the parents' views on resuscitation should be supported (Class D). There should be a consistent and coordinated approach from the obstetric and neonatal teams in applying these guidelines and in communicating with the parents in developing an agreed management plan when possible (Class D). Once resuscitation is initiated it may be appropriate to subsequently decide to discontinue cardiorespiratory support and to offer comfort care (Class IIb).

## **2. Discontinuation of Resuscitation**

Available evidence, albeit from relatively small numbers of babies, suggests that babies born without a heart rate which has not returned by 10 minutes of age are likely to either die or have severe neurological disability (LOE 4<sup>152, 153</sup>). It is not known whether there was significant selection bias in many of these studies, nor indeed that the babies included in them did receive “good quality resuscitation.” One study with a large contemporary cohort of infants (some randomized to post resuscitation hypothermia) indicates that in babies born without a detectable heart rate, the lack of ROSC after 10 minutes of age is associated with survival without severe neurological deficit in a small number of the survivors (LOE 4<sup>154</sup>).

Data are not available regarding the number of infants who were deemed too sick for study entry or died before enrollment (Class IIb). These factors may have resulted in a significant overestimation of the rate of intact survival among infants with an Apgar score of 0 at 10 minutes (Class I). In all reported series, the cause of the asphyxia and the efficacy of the resuscitation process were not elucidated. The evidence from seven (LOE 5<sup>154, 155</sup>) studies is insufficient to support or refute any recommendation regarding how much time should elapse with a heart rate <60 per minute, but above 0, before discontinuing resuscitative efforts. The evidence of outcome when the heart rate is less than 60 bpm at birth and persisting after 10 or 15 minutes of continuous and adequate resuscitative efforts at delivery is insufficient to guide decisions as to whether to withhold or to continue resuscitation (Class IIb).

### **3. Personnel needs at elective cesarean section**

Retrospective studies show that delivery by cesarean section at term under regional anesthesia is associated with a small increase in the risk of receiving mask ventilation during neonatal resuscitation in comparison with unassisted vaginal birth (LOE 4<sup>156, 157</sup>). Retrospective studies showed that delivery by cesarean section at term under regional anesthesia did not increase the risk of requirement for intubation during neonatal resuscitation in comparison with unassisted vaginal birth (LOE 4<sup>158, 159</sup>). There is no evidence addressing this question in babies born at 34-36 weeks.

When an infant without antenatally identified risk factors is delivered at term by cesarean section under regional anesthesia, a person capable of providing mask ventilation should be present at the delivery (Class D). It is not necessary for a person skilled in neonatal intubation to be present at that delivery (Class IIb).

## **9 Education for resuscitation**

### **1. Simulation**

There is a lack of uniformity in the definition of simulation as a learning methodology, determination of relevant outcomes, and use of appropriate measurement tools. Use of simulation as an adjunct to traditional education methodologies may enhance performance of healthcare professionals in actual clinical settings (LOE 1<sup>160</sup>, LOE 3<sup>161</sup>) and simulated resuscitations (LOE 1<sup>162</sup>, LOE 2<sup>163</sup>). Some studies did not show any difference in performance between standard

training and simulation training in a clinical setting (LOE 1<sup>164</sup>) or using other means of evaluation (LOE 1<sup>165</sup>). No studies were found that revealed simulation-based training produced inferior results compared with traditional methodologies.

Simulation should be used as a methodology in resuscitation education. However, the most effective interventions and evaluation methodologies remain to be defined.

## **2. Briefings and Debriefings**

Evidence from 1 prospective randomized controlled study (LOE 1<sup>166</sup>) and 17 other studies (LOE 3 to 4) of briefings and debriefings document improvement in the acquisition of content knowledge, technical skills, or behavioral skills required for effective and safe resuscitation. Only a single study (LOE 4<sup>167</sup>) revealed no effect of briefing/debriefing on performance, and no studies indicated that the use of briefings and debriefings had any negative effects.

It is reasonable to recommend the use of briefings and debriefings during learning activities while caring for simulated patients and during clinical activities.

# **■10 Neonatal resuscitation in low-income countries**

## **1. Neonatal Resuscitation Training**

One study (LOE 3<sup>168</sup>) in India and one study (LOE 3<sup>169</sup>) in Zambia demonstrated that neonatal resuscitation training improved neonatal mortality when incorporated into neonatal care training of midwives and traditional birth attendants, respectively. One study (LOE 2<sup>170</sup>) in Argentina, the Democratic Republic of Congo, Guatemala, Pakistan, and Zambia and one study (LOE 3<sup>171</sup>) in 14 centers in India did not demonstrate similar mortality reductions when training hospital physicians and nurses in neonatal resuscitation. In one study (LOE 3<sup>172</sup>) in Kenya health care workers significantly improved operational performance immediately after a 1-day modified Resuscitation Council (UK) neonatal resuscitation course. One study (LOE 3<sup>170</sup>) in Zambia demonstrated that midwives trained in neonatal resuscitation (American Academy of Pediatrics and American Heart Association Neonatal Resuscitation Program) maintain their psychomotor skills at six months, while cognitive skills declined to baseline.

There is evidence that emergency medical training programs in neonatal and trauma resuscitation should be considered in low-income countries.

## **■11 Process of the Guideline Making**

The subcommittee of Neonatal Cardio-Pulmonary Resuscitation (NCPR) dissemination project at Japanese Society of Perinatal and Neonatal Medicine (JSPNM) was requested to join the guideline making committee for Japanese version of resuscitation led by Japan Resuscitation Council (JRC) and Japan Foundation for Emergency Medicine. The ad hoc committee for revision of the guidelines for Japanese NCPR in accordance with CoSTR 2010 was established (Preparatory meeting for Consensus 2010). In establishment of this chapter, it was not possible to hear the opinions widely from relevant people concerning determination of the guideline for Japanese NCPR. Thus, in preparatory meeting for Consensus 2010, 72 worksheet summaries available at the website were translated in to Japanese and were uploaded at the homepage of JSPNM from May 17<sup>th</sup>, 2010 to gather opinions from the members. After receiving the final version of CoSTR 2010 under nondisclosure obligation from ILCOR headquarter, this translated worksheets were deleted from the homepage at June 8<sup>th</sup> to avoid any misunderstandings.

The guidelines for Japanese NCPR in accordance with CoSTR 2005 were established only by members recommended by Japan Pediatric Society. However, since in Japan, almost half of deliveries are taking place at facilities where pediatrician is not present, so this time we included members recommended by Japan Society of Obstetrics and Gynecology.

Although recommended by CoSTR 2010, some parts of methods were not recommended or had to lower the recommendation level in Japan because of the differences, from the Europe and North America, of delivery systems and the high prevalence of jaundice in Japanese population. For those parts, adequacy of recommendation and class of recommendation should be decided based on the results from clinical trials of high quality confirming efficacy and safety. Those points are discussed as “Knowledge gaps” at the end of each chapter.

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