

Managing Oxygen Therapy during Delivery Room Stabilization of Preterm Infants

Jennifer A. Dawson, RN, RM, PhD^{1,2,3}, Maximo Vento, PhD, MD⁴, Neil N. Finer, MD⁵, Wade Rich, BSHS, RRT, CCRC⁵, Ola D. Saugstad, PhD, MD⁶, Colin J. Morley, MD, FRCPC^{1,2,3}, and Peter G. Davis, MD^{1,2,3}

In October 2010, the International Liaison Committee on Resuscitation released new guidelines for neonatal resuscitation, which expanded on the previous recommendations for the use of pulse oximetry during neonatal resuscitation. In this Commentary, we discuss oxygen treatment in the delivery room. Where available, we have used evidence from randomized controlled trials (RCTs). Where this evidence is lacking, we have relied on observational and animal data to inform our strategy for using supplemental oxygen in the delivery room.

"Normal" Oxygen Saturation Values in Newborn Infants

Early-generation pulse oximeters took several minutes to provide an accurate reading and, thus, were not useful for making decisions during neonatal resuscitation. However, modern pulse oximeters, when applied properly, can provide measurements within 90 seconds of birth.¹⁻⁵ Studies measuring oxygen saturation (SpO₂) using pulse oximetry immediately after birth in term neonates have shown that it takes at least 5 minutes for preductal SpO₂ to rise from ~50% to >90%.^{2,3,6-10} Preterm infants have slightly lower SpO₂ than term infants in the first 10 minutes after birth.^{3,7,11,12} Our pulse oximetry findings from a cohort of 468 infants (25-42 weeks' gestation) who did not receive oxygen or other interventions in the delivery room are similar to those of others.^{1,12-15} We used these data to construct charts illustrating the 10th-90th percentiles for SpO₂ at 1-10 minutes after birth. The percentile lines represent the proportion of infants with SpO₂ values below each percentile at each time point (Figure).¹¹ As shown, healthy newborn infants have a wide range of SpO₂ values.

Oxygen Administration in the Delivery Room

In the neonatal intensive care unit (NICU), oxygen is administered in response to the infant's color, blood gas values, transcutaneous O₂ monitoring, or SpO₂ measured with a pulse oximeter. In most NICUs, the infant's fraction of

inspired oxygen (FiO₂) is adjusted to maintain SpO₂ within a target range. This range may differ among NICUs, but the common goal is to avoid hypoxia and hyperoxia. The International Liaison Committee on Resuscitation's 2010 guidelines suggest using pulse oximetry to guide oxygen treatment in the delivery room¹⁶ to avoid hyperoxia and hypoxia, particularly in extremely preterm infants. Suggested target pulse oximetry levels at intervals after birth have been provided.¹⁷

The practice of using 100% rather than 21% oxygen in the delivery room has been associated with increased neonatal mortality.^{18,19} Studies by Vento and coworkers²⁰⁻²² and Saugstad and coworkers²³⁻²⁶ have shown that delivery of high oxygen concentrations during resuscitation is associated with short-term and long-term morbidity. A limitation of these trials and meta-analyses is that they enrolled mostly term or late-preterm newborns.

Evidence from both RCTs^{4,27-32} and observational studies^{33,34} suggests that preterm infants can be successfully treated in the delivery room with less than 100% oxygen. Two RCTs^{27,32} and 2 observational studies^{33,34} have shown that active management of FiO₂ using pulse oximetry is possible and can prevent hyperoxia. Interestingly, even though these studies had different criteria for starting oxygen, they all demonstrated that most extremely preterm infants eventually require some supplemental oxygen in the delivery room.^{27,32-34}

Use of Pulse Oximetry in the Delivery Room

Many clinicians have experience in applying pulse oximeter sensors in the NICU. However, the delivery room is a challenging environment, and most operators find that their ability to obtain data quickly improves with experience. Data are most quickly available if the device is applied in the following order: (1) turn on the oximeter; (2) apply the sensor to the infant's right hand or wrist; (3) connect the sensor to the oximeter cable; and (4) shield the sensor from light.^{35,36} The sensor is placed on the right hand or wrist to reflect the

CPAP	Continuous positive airway pressure
FiO ₂	Fraction of inspired oxygen
NICU	Neonatal intensive care unit
PEEP	Positive end-expiratory pressure
RCT	Randomized controlled trial
SpO ₂	Oxygen saturation

From the ¹Neonatal Services, The Royal Women's Hospital; ²Murdoch Children's Research Institute; ³Department of Obstetrics and Gynaecology, University of Melbourne, Melbourne, Australia; ⁴Neonatal Research Unit, Division of Neonatology, University Hospital La Fe, Valencia, Spain; ⁵Division of Neonatology, Department of Pediatrics, University of California San Diego, San Diego, CA; and ⁶Department of Pediatric Research, University of Oslo, Oslo University Hospital, Oslo, Norway

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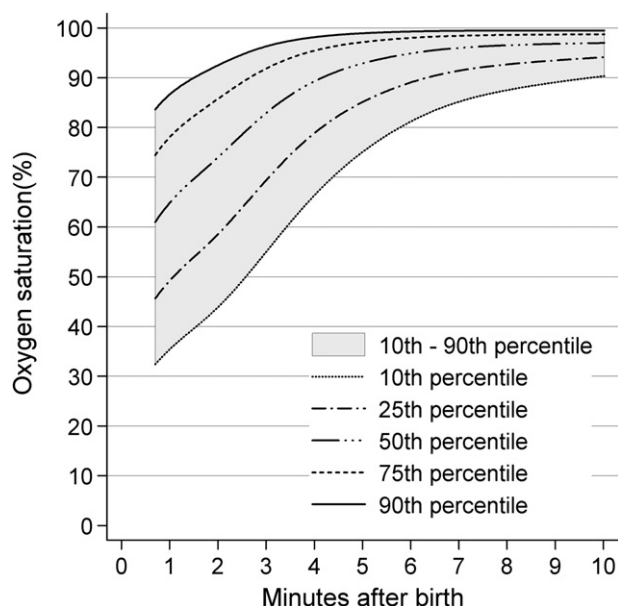


Figure. The 10th, 25th, 50th, 75th, and 90th SpO₂ percentiles from term infants (≥ 37 weeks' gestation) with no medical intervention after birth.¹¹ The shaded area indicates SpO₂ values between the 10th and 90th percentiles.

SpO₂ of blood flow to the brain.¹⁴ SpO₂ measured from a foot is substantially lower than that measured in the right hand for many minutes after birth.^{13,14}

Identification of Appropriate SpO₂ Targets

The American Heart Association cautions the clinician against excessive use of oxygen, especially in preterm infants.³⁷ There is agreement that hypoxia and hyperoxia should be prevented in newborn infants; however, an appropriate SpO₂ target below which oxygen therapy does more good than harm during resuscitation has not yet been determined. The highest safe level of SpO₂ also is unclear. Even short-term exposure to a high FiO₂ can generate reactive oxygen and nitrogen species.^{21,31} These free radicals are associated with short- and long-term morbidity, with preterm infants at greatest risk of harm from exposure to excess oxygen.^{21,25,31} There are insufficient data from very preterm infants to develop gestational age-specific normal SpO₂ ranges.^{3,7,11}

To date, no RCT has indicated the appropriate SpO₂ target range in the delivery room. In the American Heart Association's 2010 newborn resuscitation algorithm, the preductal SpO₂ target ranges at 1, 2, 3, 4, 5, and 10 minutes after birth are 60%-65%, 65%-70%, 70%-75%, 75%-80%, 80%-85%, and 85%-95%, respectively.¹⁷ These values are close to the median values for infants who do not require resuscitation.¹¹ In contrast, the European Resuscitation Council's newborn life support algorithm recommends starting oxygen at an SpO₂ of 60%, 70%, 80%, 85%, and 90% at 2, 3, 4, 5, and 10 minutes after birth, respectively. These values are closer

to the 25th percentile¹¹; however, the targets from both algorithms are sufficiently similar for practical use.

There are several possible reasons for the differences in the American Heart Association- and European Resuscitation Council-recommended SpO₂ levels for starting oxygen. First, there is no evidence to indicate whether SpO₂ targets should be chosen based on saturation values measured in preterm infants not receiving medical interventions in the delivery room or those measured in their term counterparts. Second, the appropriate SpO₂ percentile at which to commence oxygen supplementation has not been determined in RCTs. It is important to remember that if the 50th percentile is chosen, then 50% of normal infants will have a "low" SpO₂. If the target SpO₂ percentile is too low, then hypoxic damage may result. If the target SpO₂ percentile is set too high, then clinicians will provide unnecessary oxygen treatment, possibly resulting in oxygen toxicity.

Data from term infants who received no interventions in the delivery room were used to construct a normal range of SpO₂ in the first 10 minutes after birth (Figure). A saturation-tracking system has been developed (W.R. at University of California San Diego) that displays real-time FiO₂ and SpO₂ values plotted against high and low SpO₂ targets using a data acquisition system, an Excel chart, and a netbook computer.

Clinical assessment of the infant is important before starting oxygen therapy. However, clinical assessment of color and heart rate are subjective and unreliable.³⁸ Many healthy infants do not appear pink until several minutes after birth; this is normal and does not mean that they need oxygen treatment. But an infant who is unresponsive, hypotonic, and bradycardic requires prompt intervention. Important signs of an infant's satisfactory transition regardless of the pulse oximetry measurements are a rising heart rate, improving muscle tone, and spontaneous breathing.¹⁶

Strategies to Improve Oxygenation in the Delivery Room

Oxygen treatment in a newborn infant will not be effective if the infant's lungs are not aerated and gas is unable to cross the alveolar epithelium. The first step in improving oxygenation is not oxygen treatment, but rather lung aeration and establishment of a functional residual capacity.³⁹⁻⁴² The most effective way to achieve this is with continuous positive airway pressure (CPAP) if the infant is breathing but has respiratory difficulty. If the infant is not breathing adequately, then intermittent positive-pressure ventilation with positive end-expiratory pressure (PEEP) should be used. According to the International Liaison Committee on Resuscitation, PEEP is likely to be beneficial during the initial stabilization of apneic preterm infants who require intermittent positive-pressure ventilation and should be used if the necessary equipment is available.¹⁷ The most reliable device for providing CPAP or PEEP in the delivery room is a T-piece resuscitator. A self-inflating bag fitted with a PEEP valve can provide PEEP during ventilation,

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