Oxygen Therapy in the Delivery Room

What Is the Right Dose?

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KEYWORDS

• Oxygen • Oxygen saturation • Newborn • Resuscitation • Delivery room

KEY POINTS

- Oxygen delivery depends on multiple factors, including fraction of inspired oxygen, ventilation, pulmonary blood flow, cardiac output, hemoglobin type and content, and local tissue factors.
- The goal of oxygen therapy is normoxia and is achieved by avoiding oxygen toxicity owing to excess oxygen exposure while delivering sufficient oxygen to prevent hypoxia.
- Initiate resuscitation with 21% oxygen in infants 35 weeks gestational age or older and 21% to 30% oxygen in preterm infants less than 35 weeks gestational age.
- Titrate oxygen to maintain oxygen saturations that are an approximation of the interquartile range of oxygen saturations of healthy term newborns delivered vaginally at sea level.
- Further research is urgently needed as the current recommendations are based on a low to moderate quality of evidence.

INTRODUCTION

Oxygen is the single most commonly used medication during resuscitation of the newborn in the delivery room (DR). The goal of oxygen therapy is to prevent hypoxemia and hyperoxemia, because both can have detrimental effects on the health of the newborn.[1,2] To achieve this goal, DR care providers must accurately recognize the need for oxygen in the newborn after birth and adjust the fraction of inspired oxygen (Fio_2) as needed while simultaneously ensuring adequate ventilation. This article reviews the unique physiology of fetal and newborn oxygenation, oxygen transport,

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and delivery; different techniques to measure adequacy of oxygen therapy in the DR; the importance of appropriate oxygen therapy during this critical transition period; and the current recommendations for oxygen therapy and its limitations.

OXYGEN FROM A PHYSIOLOGIC PERSPECTIVE

To understand optimal oxygen therapy in the DR, understanding oxygen physiology during fetal transition from the low-oxygen intrauterine environment to the high-oxygen extrauterine environment is essential. Oxygen is a critical fuel source for aerobic metabolism and is required in numerous crucial oxidative metabolic reactions.[3] A constant and adequate supply of oxygen at the cellular level is vital. Oxygen physiology can be conceptualized in 3 steps: oxygenation, oxygen delivery, and oxygen consumption. Oxygenation is the process by which oxygen diffuses passively from the alveolus to the pulmonary capillary. High altitude, hypoventilation, ventilation–perfusion mismatch, and limited diffusion owing to lung disease or right-to-left shunts owing to congenital cardiac anomalies can affect oxygenation.[3] Most of the oxygen is bound to hemoglobin, but some dissolves in plasma. Oxygen delivery is the rate of oxygen transport from the lungs to the peripheral tissues. Oxygen delivery depends on the oxygen content of the blood and cardiac output.[3] The oxygen content of the blood depends on hemoglobin and oxygen saturation. The rate at which peripheral tissues remove oxygen from the blood is called oxygen consumption. Hypoxia arises when the oxygen supply is inadequate to meet the demands of the peripheral tissues. Hypoxia can occur owing to inadequate oxygenation, inadequate oxygen delivery, or very high oxygen consumption. Hypoxemia is defined as an abnormally low level of oxygen in the blood. Hyperoxemia, or excess oxygen in the blood, can lead to oxidative stress and cause tissue damage. The goal of oxygen therapy is to achieve normoxia, which is discussed in additional detail elsewhere in this article.

FETAL OXYGEN DELIVERY

The fetus thrives in the low-oxygen intrauterine environment where the partial pressure of oxygen in the descending aorta is close to 18 mm Hg.[4–7] The highest partial pressure of oxygen in the umbilical vein is close to 30 mm Hg.[8] The fetus is able to maintain normoxia in this low oxygen environment owing to

- Fetal hemoglobin (HbF): HbF shifts the oxygen–hemoglobin dissociation curve to the left (**Fig. 1**). This increases the affinity of hemoglobin for oxygen and allows efficient loading of oxygen in the low-oxygen environment of the placenta. HbF allows efficient unloading of oxygen from the blood to peripheral tissues owing to the steepness of the oxygen–hemoglobin dissociation curve.[3]
- Elevated hemoglobin levels: The higher hematocrit of the fetus compared with adults increases the oxygen content of the blood.[3]
- High cardiac output: Fetal cardiac output is 4 times higher than that of adults.[3,9,10] This improves oxygen delivery even at such low oxygen saturations.[3]

TRANSITION FROM THE INTRAUTERINE TO EXTRAUTERINE ENVIRONMENT

On average, the HbF saturation is around 50% during labor.[11–13] It takes approximately 10 minutes after birth to achieve oxygen saturation close to 90% in spontaneously breathing healthy term and late preterm newborns.[14,15] The transition from fetus to newborn is a complex process.[3,8,16,17] After birth, fluid in the alveoli is absorbed and replaced by air.[18] As a result of gaseous distension and possibly increased oxygen in the alveoli, pulmonary vascular resistance decreases.[19] The decrease in the