

Pattern of Oxygen Saturation (SpO₂) Immediately After Birth In Neonates

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ABSTRACT

Objective: To determine the mean SpO₂ trend during the first 10 minutes after birth in healthy neonates and also to compare mean SpO₂ values between term and preterm infants.

Study Design: Prospective comparative study

Place and Duration of Study: Children Hospital, Pakistan Institute of Medical Sciences (PIMS), Islamabad, Pakistan, from Mar to Aug 2023.

Methodology: A total of 100 newborns were enrolled. Neonates meeting the criteria were seen in the gynecology/obstetrics operation theatre and labor room. SpO₂ monitoring commenced at 1 minute post-birth by applying a pulse oximeter to the newborn's right foot and recording values at 1 min, 5 min, and 10 minutes of life.

Results: Out of 100 neonates, 50% were male, and 50% were female. The mean weight was 2.93±0.54 kg. There were 30% preterm deliveries and 70% term deliveries. The mean SpO₂ values were 76.13±10.41% at 1 minute, 89.68±6.62% at 5 minutes & 95.84±3.65% at 10 minutes of life. Mean SpO₂ was significantly higher in term babies as compared to preterm babies at 1 minute & 5 minutes, while at 10 minutes it was not statistically significant.

Conclusion: We concluded that SpO₂ of both types of neonates, i.e., preterm and term, reached normal within 10 minutes. However, the average SpO₂ level at 1 min and at 5min of preterm neonates was low as compared to the term neonates.

Keywords: Birth asphyxia, Neonates, Pulse oximetry, SpO₂ values, Term/preterm infants

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INTRODUCTION

Birth asphyxia is a serious clinical problem worldwide, especially in developing countries¹ like Pakistan. Globally, approximately one quarter of all neonatal deaths result from birth asphyxia. Reported global figures for neonatal deaths attributed to non-specific conditions of hypoxic-ischemic encephalopathy (HIE) range from 0.7 million to 1.6 million per year. Ninety-nine percent of the deaths occur in middle- and low-income countries². It is, however, a treatable problem, and early identification and effective resuscitation at birth can prevent large morbidity and mortality³.

The Apgar score (AS) is routinely used for assessing newborns immediately after birth. It is, however, a subjective evaluation and a poor predictor of mortality associated with HIE; several factors influence it, such as trauma, infections, congenital anomalies, drugs, and prematurity other than hypoxemia. Especially, one of its variables, body colour, is highly unreliable in detecting oxygen

saturation levels at birth and has an observer bias⁴.

Pulse oximeters, on the other hand, are a more reliable indicator of oxygen saturation values and are based on red and infrared light absorption characteristics of oxygenated and deoxygenated hemoglobin⁵. Some pediatricians believe they can consistently identify infants based on physical findings alone, while many consider pulse oximeters to be unreliable⁶. However, modern oximeters are stable and dependable, with a very low false positive rate. Therefore, experts recommend routine use of a pulse oximeter, which will not only help in determining baseline SpO₂ values in normal newborns, but also guide more efficiently adequate oxygen therapy where necessary to prevent hypoxia on one hand and oxygen toxicity on the other, especially in preterm newborns^{7,8}.

Currently, pulse oximeters are not being used routinely during neonatal resuscitation universally. Also, there are no studies regarding the normal ranges of oxygen saturation in newborn infants in Pakistan.⁹ The average SpO₂ values in studies available were 62±6.25% at the first minute, 86±3 at 5% minutes & 94±1.5% at 10 minutes of life in preterm infants. 68±4.25% at 1 minute, 92±3.25% at 5 minute & 97±1 at

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10% minutes of life in term infants. $66 \pm 5\%$ in all infants at 1 minute, $89 \pm 3.25\%$ at 5 minute and $96 \pm 1.5\%$ at 10 minutes.¹⁰

Traditionally, oxygen levels in newborns have been assessed clinically, and there is substantial variability in assessment of colour¹⁰. My study aims to measure Spo2 values in the first minutes after birth in normal newborns who did not receive any resuscitation and to use these values as reference ranges to guide Oxygen supplementation in the delivery room.

METHODOLOGY

This Prospective comparative study was conducted in the Children's Hospital, Pakistan Institute of Medical Sciences (PIMS), Islamabad, Pakistan, from Mar to Aug 2023. The sample size was calculated with the WHO sample size calculator 7.1, with a confidence level of 95%, absolute precision of 1, and the population standard deviation was considered from the reference study $61 \pm 5\%$ ¹¹. The minimum sample size to estimate the mean SpO2 at 1 minute, with the help of the stats mentioned above, was 97. Hence, we took 100 complete cases in our study.

Inclusion Criteria: All healthy newborn babies, regardless of whether they were delivered at term or preterm, via normal vaginal delivery or by cesarean section, were included in the study, with no gender differences considered.

Exclusion Criteria: Newborns requiring supplemental oxygen or any kind of assisted ventilation soon after birth, those with congenital anomalies, newborns with growth retardation, and babies born to mothers with complicated pregnancies (acute or chronic infection, fever, anemia, oligohydramnios, rupture of membranes ≥ 18 hours, pre-eclampsia, eclampsia) or taking any treatment for any prolonged illness were excluded.

Non-probability sampling technique was used. Data were collected after approval by the Institutional Ethical Review Board with approval certificate No IERB-02/2023, Dated: 03-01-2023. Informed verbal consent was taken from the parents/caregivers of neonates fulfilling the study criteria before enrolment. Neonates meeting the criteria were seen in the gynecology/obstetrics operation theatre and labor room. SpO2 monitoring commenced at 1 minute post-birth by applying a pulse oximeter to the newborn's right foot and recording values every 1 minute till 10 minutes of life. The mean of SpO2 values at 1, 5 and 10

minutes was taken. All the data were collected on a structured proforma.

All collected data were cross-checked by the study investigator on a daily basis. Before data entry, all forms were checked for completeness and consistency.

Data analysis was done using Statistical Package for Social Sciences version 23.0. The descriptive analysis of qualitative variables in the study was presented in the form of frequency and percentage. One-sample t-test was applied to estimate the lowest SpO2 level at 1 minute, 5 minutes, and 10 minutes of life. Independent-samples t-test and ANOVA were used to compare the mean SpO2 between neonatal gestational duration groups, neonatal sex, neonatal weight categories, and between neonate groups based on status of maternal risk factors. Regression analysis was used to predict SpO2 at different times. A p-value of ≤ 0.05 was considered significant.

RESULTS

Out of 100 neonates, the male-to-female ratio was 1:1. Maternal risk factors were present in 14 neonates. The basic characteristics of the neonates are mentioned in Table-I.

Table-I: Basic neonatal characteristics (n=100)

Variables	Mean $\pm$ Standard deviation	Minimum	Maximum
Gestational age (weeks)	37.08 ± 2.11	32	40
Neonatal weight (kg)	3.00 ± 0.50	1.4	4
SpO2 (%) at 1 min	76.22 ± 10.20	45	87
SpO2 (%) at 5 min	89.37 ± 6.69	74	99
SpO2 (%) at 10 min	95.84 ± 3.66	88	99

*SpO2 - Partial Pressure of Oxygen

On the basis of our sample results, we concluded that the mean SpO2% is at least 74 with a p-value of 0.016 at 1 minute, at least 88 with a p-value of 0.022 at 5 minutes, and at least 95 with a p-value of 0.012 at 10 minutes. (Figure)

Out of 100 neonates, there were 30 preterm, and the remaining 70 were born at term. The line chart showed that the mean SpO2 of preterm neonates was significantly lower at 5min $87.03 \pm 6.96\%$ as compared to the neonates who were born at term $90.37 \pm 6.36\%$, with p-value 0.021; whereas the difference of SpO2, at 1 min of life $72.93 \pm 13.83\%$ versus $77.63 \pm 7.89\%$ and at 10 min of life $94.77 \pm 4.31\%$ versus $96.30 \pm 3.27\%$, was not significantly different with p-Value 0.09 and 0.088, respectively. The variation in SpO2 at 1 min, 5 min,

and 10 min with respect to other neonatal characteristics is mentioned in Table-II.

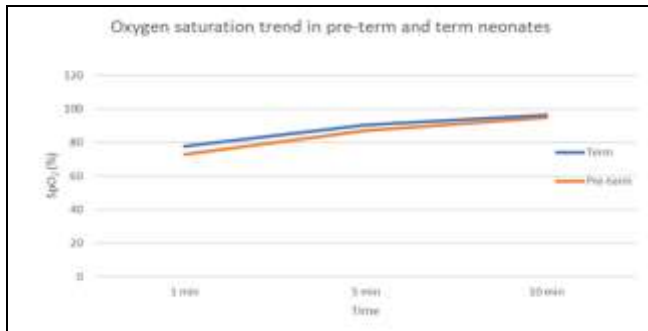


Figure: Line chart of mean SpO2 at different times with respect to gestational age

The above table shows that the low neonatal birth weight, presence of maternal risk factors, and the sex “female” have significantly lower SpO2 as compared to the other neonates. The relation of the above neonatal characteristics with SpO2 is measured through linear regression analysis and mentioned in Table-III.

Table-II: Comparison of mean SpO2 with respect to basic neonatal characteristics (n=100)

	Neonatal birth weight			p-value
	Low (<2.5 kg) (n=9)	Normal (2.5-3.5 kg) (n=86)	Overweight (> 3.5 kg) (n=5)	
SpO2 (%) at 1 min	61.56 ± 10.21	77.70 ± 9.17	77.20 ± 7.12	<0.001
SpO2 (%) at 5 min	82.67 ± 4.66	89.90 ± 6.54	92.40 ± 6.03	0.004
SpO2 (%) at 10 min	91.78 ± 2.22	96.26 ± 3.59	96 ± 2.74	0.002
Maternal risk factors				
	Yes (n=14)	No (n=86)		p-Value
SpO2 (%) at 1 min	62.36 ± 12.76	78.48 ± 7.72		<0.001
SpO2 (%) at 5 min	82.93 ± 5.76	90.42 ± 6.25		<0.001
SpO2 (%) at 10 min	91.36 ± 3.63	96.57 ± 3.12		<0.001
Gender of the neonates				
	Male (n=50)	Female (n=50)		p-Value
SpO2 (%) at 1 min	78.94 ± 7.22	73.50 ± 11.97		0.007
SpO2 (%) at 5 min	91.22 ± 6.53	87.52 ± 6.39		0.005
SpO2 (%) at 10 min	96.98 ± 3.16	94.70 ± 3.80		0.002

*SpO2 – Partial Pressure of Oxygen

Table-III: Regression analysis to predict SpO2 at different times

	Unstandardized coefficients (standard error)	Standardized coefficient	p-Value	95% Confidence interval
SpO2 at 1 min				
Maternal risk factor	-8.39 (3.81)	-0.041	0.030	-15.95 – -0.83
Gestational age	32.35 (1.66)	0.839	< 0.001	29.06 – 35.65
Weight category	9.56 (2.44)	0.171	< 0.001	4.73 – 14.39
SpO2 at 5 min				
Maternal risk factor	1.102 (413)	0.005	0.790	-7.10 – 9.30
Gestational age	35.69 (1.80)	0.795	< 0.001	32.12 – 39.26
Weight category	13.33 (2.64)	0.205	< 0.001	8.09 – 18.57
SpO2 at 10 min				
Maternal risk factor	3.61 (4.24)	0.014	0.397	-4.8 – 12.01
Gestational age	36.71 (1.85)	0.763	< 0.001	33.04 – 40.37
Weight category	16.36 (2.71)	0.235	< 0.001	10.99 – 21.73

*SpO2 – Partial Pressure of Oxygen

The R-square of the regression model for SpO2 at 1min was 0.974, at 5 min was 0.975, and at 10 min was 0.977, showing that these three parameters explained the variability of SpO2 sufficiently. It also showed that maternal risk factors play a significant role only in the prediction of SpO2 at 1 minute and were not a significant independent factor in the other two models. The result showed that with an increase in gestational age from preterm to term, there is a 9.56% increase in SpO2 at 1 min. Similarly, with the change of the neonatal weight group from low weight to normal and normal to overweight, there is an increase in SpO2 at 1 min by 16.36%.

DISCUSSION

The study found that healthy term newborns achieved normal postnatal SpO₂ gradually, with the transition typically requiring more than 5 minutes. Many newborns had SpO₂ <90% during the first 5 minutes of life, highlighting the importance of considering the normal physiological rise in oxygen saturation when setting oxygen targets and assessing the need for resuscitation in the delivery room.

A neonate undergoes significant physiologic changes during the transition from intrauterine to the extra-uterine period.¹² For the majority of newborn babies, this transition occurs smoothly; however, approximately 5-10% may require some assistance with breathing, and about 1% may necessitate extensive resuscitation. The indications and timing of supplemental oxygen therapy to assist the newborn during this transition have also been reported by Morton *et al.*¹³ Traditionally, the oxygenation levels of newborn infants have been assessed clinically.¹⁴ However, research conducted by Robbins *et al.*, revealed significant variability among observers in assessing color, both interobserver and intraobserver. Therefore, the experts have recommended the use of pulse oximetry to accurately measure oxygenation in this setting.¹⁵

This study reports on the changes in SpO2 values in infants during the first 10 minutes of life. Immediately after birth, a pulse oximeter was applied, and serial monitoring of oxygen saturation was carried out starting at 1 minute and recording values after every 1 minute till 10 minutes of life. SpO2 value increased steadily over time, taking approximately 8 minutes to exceed 90% in term infants. We found that the average SpO2 values were 76.13±10.41 at the first minute, 89.68±6.62 at 5 minutes & 95.84±3.65 at 10 minutes of life in infants. A study done by Torp *et al.*,

showed that mean SPO₂ at 1 min was 74.5±13.8 and 66.35±11.37 with babies born via normal vaginal delivery (NVD) and caesarean section (C/S) respectively, 84.4±6.37 and 82.65±4.97 at 5 mins via NVD and C/S respectively and at 10 mins it was noted 89.14±5.5 and 87.95±7.94 in infants born via NVD and C/S respectively.^{16,17} The results are almost similar at 1 minute but a bit different at 5 and 10 minutes. Also, we didn't measure spo₂ value separately according to mode of delivery.

We also compared mean SpO₂ between male infants and female infants at 1, 5, and 10 minutes, and the results were statistically significant, while the study conducted by Reddy et al., found that the relation between gender and Spo₂ was not statistically different.¹⁸

Mannan et al., measured the SpO₂ of 50 healthy term infants and observed that SpO₂ at 2 minutes of age could be as low as 34%. These infants took between 12 and 14 minutes to reach SpO₂ values equal to 95%. In their study of healthy term neonates, Kamlin et al. 21 found that the median (interquartile range) SpO₂ at 1 minute was 63% (53%-68%). There was a gradual rise in SpO₂ over time, with a median SpO₂ at 5 minutes of 90% (79%-91%).¹⁹

It was also found that there is a significant difference in Spo₂ of preterm and term neonates. The mean SpO₂ of preterm neonates was significantly lower at 5 minutes as compared to the term neonates, while there was no significant difference in SpO₂ at 1 and 10 minutes between term and preterm babies. A literature report conducted a study on infants of less than 35 weeks who did not receive supplemental oxygen in the delivery room. They reported slightly higher SpO₂ values over the first minutes and a shorter time to reach an SpO₂ of 90% compared to the findings in our study.

In our study, the mean SpO₂ was also significantly higher in those neonates whose weight was above 2.5 kg. Nair et al., reported results that are against our study who showed that mean SpO₂ was higher in neonates with a low birth weight.⁴ It varied from 98.3% in the newborns with a birth weight of 2750–2999 grams to 97.6% in those with a weight above 4500 grams.

LIMITATION OF STUDY

This single-center study included a relatively small sample of healthy neonates and excluded newborns requiring oxygen or assisted ventilation, which limits the generalizability of the findings to high-risk infants and other

clinical settings. The study occurred in a lower-income public hospital. In addition, SpO₂ was measured only during the first 10 minutes after birth, and outcomes were not analyzed separately by mode of delivery.

CONCLUSION

In conclusion, the transition to normal postnatal SpO₂ typically takes more than 5 minutes in healthy newborns. In healthy term infants, oxygen saturation increases gradually, and monitoring SpO₂ may aid in identifying infants requiring resuscitation to prevent overexposure to high O₂ concentrations after birth. It is important to note that many newborns exhibit an SpO₂ <90% during the first 5 minutes of life. This aspect should be taken into consideration when determining SpO₂ targets for infants receiving supplemental oxygen in the delivery room

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Authors' Contribution

Following authors have made substantial contributions to the manuscript as under:

IT & SM: Data acquisition, data analysis, critical review, approval of the final version to be published.

AQ & MK: Study design, data interpretation, drafting the manuscript, critical review, approval of the final version to be published.

IH: Conception, data acquisition, drafting the manuscript, approval of the final version to be published.

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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Pattern of Oxygen Saturation (Spo2) Immediately

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