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STUDY OF SpO2 TRENDS IN HEALTHY TERM AND PRETERM NEONATES DURING FIRST 10 MINS OF LIFE

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ABSTRACT

INTRODUCTION: Oxygen is essential for the successful progression of physiological activities of human beings. The transition from intrauterine to extra uterine life is generally smooth; however a small fraction of neonates (5-10%) needs some assistance in breathing and a relatively much smaller (1%) requires extensive resuscitation[1,2]. The indications and timing of supplemental oxygen therapy to assist the newborn in this transition has been a matter of debate[3-8]. It has been shown in literature that in healthy term neonates, the SpO2 of 90% or above is achieved within 10 minutes of birth[9]. The preterm neonates have different SpO2 trends as compared to healthy term neonates during the initial few minutes of birth as the fetus is accustomed to relatively low oxygen exposure and the mechanisms for managing high oxygen levels are not yet completely developed[10]. Although there is plenty of data on this issue arising from western literature, there is lack of such studies in Indian environment, hence, the present study was planned with an aim to study the trends in neonatal SpO2 levels during the first 10 minutes as a comparative study between preterm and healthy term neonates and also to evaluate the impact of mode of delivery.

METHODS: It is a Prospective observational study carried out in the Department of Paediatrics SBKS,MI&RC. All healthy term and late preterm (completed 34 weeks to 36wks 6days) newborns were enrolled in the study where their SpO2 was monitored for the first ten minutes of their birth with the help of pulse oxymeter**.**

RESULTS: In present study, in an overall sample of 145 neonates (93 term and 52 preterm), the normative range for SpO2 in neonates was 61.38 to 62.46%, 66.63 to 67.73%, 71.66 to 72.71% 77.06 to 78.11%, 82.16 to 83.12%, 61.38 to 62.46%, and 90.82 to 91.13% at 1 min, 2min, 3 min, 4 min, 5 min, 7 min and 10 min of life respectively. The normative range of SpO2 in preterm neonates was 58.77-59.35%, 64.17-64.63%, 69.13-69.91%, 74.80-75.50%, 80.16-81.03%, 84.15-84.96% and 88.23-88.89% at 1 min, 2min, 3 min, 4 min, 5 min, 7 min and 10 min of life respectively.

CONCLUSION: In present study, mean SpO2 levels were significantly higher in full term neonates as compared to preterm neonates throughout the evaluation period.

KEYWORDS : Term, Preterm, Oxygen saturation.

INTRODUCTION

In adults, the normal SpO2 levels are supposed to be ≥95%. However, in neonates, the SpO2 levels are much below the 95% level during the first few minutes of life[11]. The fetus normally exists in an environment of relatively low oxygen exposure and the mechanisms for managing high oxygen levels are not yet completely developed. Oxygen is essential for adequate cellular functioning and highly specialized systems have developed to maintain a delicate balance during conditions of relatively low to high levels of oxygen availability. However, despite such sophisticated controls , prolonged or severe exposures to both excessively low and high oxygen levels may lead to tissue damage. In the fetus, SpO2 of blood is about 50–60%[12]. Many things must change for a successful transition from fetal to neonatal life. One of them is the progressive increase in arterial SpO2 (SaO_2) until the normal neonatal SaO_2 in room air (95 to 100 cm of H_2O/mm Hg) is reached[13]. It take several minutes after birth, and, hence one should not aim for a saturation >90% immediately after birth[14,15]. Thus, evidence has shown that transition from a hypoxic state with blood SpO2 from 50 to 60% during intrauterine period to >95% during extrauterine period is dependent on the gestational age.Hence,the extrauterine SpO2 in preterm neonate is assumed to be lower than that observed in a term neonate. However, it has been shown in literature that in healthy term neonates, the SpO2 of 90% or above is achieved within 10 minutes of birth[9]. The preterm neonates have different SpO2 trends as compared to healthy term neonates during the initial few minutes of birth as the fetus is accustomed to relatively low oxygen exposure and the mechanisms for managing high oxygen levels are not yet completely developed[10]. Although, there is plenty of data on this issue arising from western literature, there is lack of such study in Indian environment, hence, the present study was planned with an aim to study the trends in neonatal SpO2 levels during the first 10 minutes as a comparative study between preterm and healthy term neonates and also to evaluate the impact of mode of delivery. Thus, the aim of this study is to define reference ranges for pulse oxygen saturation (SpO_2) values in the first 10 minutes after birth for term and preterm infants using pulse oxymeter.

MATERIALS AND METHODS

Study was conducted at Dhiraj Hospital, affiliated to Smt. B.K. Shah Medical Institute and Research Centre, Vadodara. Total 145 neonates were enrolled in the study. It was Prospective observational study. All healthy term and late preterm (completed 34 weeks to 36wks 6days) newborns delivered by normal vaginal delivery and cesarean and APGAR 7 at 1minute were included in the study and those neonates delivered by grand multipara, pre-eclampsia, eclampsia mother, mother on long term therapy, neonates having any heart disease, infants born with congenital malformation, and neonates who required resuscitation were excluded from the study.

METHODOLOGY:

All healthy term and pre term neonates born by normal vaginal / caesarean delivery were enrolled in the study. A written and informed consent was obtained from the mother before delivery in all cases. All the neonates enrolled in the study were monitored for SpO2 for the first ten minutes of their birth with the help of pulse oxymeter.

The sensors were placed on the right hand. The sensors were then connected to the oxymeter, as recommended for faster acquisition of the values. The time taken to apply the sensor and to obtain the display was noted. The readings were recorded at 1, 2, 3, 4, 7 and 10 minutes of

birth. The care of the neonate was not interrupted while doing this procedure. The sensors remained attached even when the baby was handed over to the mother. The APGAR score assigned by the care giver was also noted simultaneously."

RESULTS

The present study was carried out with an aim to define reference ranges for pulse SpO2 (SpO_2) values in the first 10 minutes after birth for term and preterm infants using pulse oxymeter. For this purpose, a total of 145 neonates were enrolled in the study immediately after the delivery. There were 75 male and 70 female newborns. Out of 145 patients, 93 were delivered by vaginal route and rest by cesarean section, 93 were full term and 52 were preterm.

Table No-1

SN	Time after birth	SPO2	Change from baseline (1 min)					Change from immediate preceding measurement				
			Mean	SD	% Change from baseline	't'	'p'	Mean	SD	% Change from baseline	't'	'p'
1.	1 min	57 to 68% (mean of 61.92±3.30 SD,95% CI 61.38 to 62.46)										
2.	2 min	63 to 73% (67.18±3.34 SD, 95% CI 66.63 to 67.73)	5.26	1.20	8.50	-52.72	<0.001	5.26	1.20	8.50	-52.72	<0.001
3.	3 min	66 to 78% (mean of 72.19±3.20 SD, 95% CI 71.66 to 72.71)	10.27	1.40	16.58	-88.28	<0.001	5.01	1.31	7.45	-45.85	<0.001
4.	4 min	73 to 85% (mean of 77.56±3.18 SD, 95% CI 77.06 to 78.11)	15.67	1.55	25.31	-122.06	<0.001	5.40	1.40	7.48	-46.57	<0.001
5.	5 min	76 to 88% (mean of 82.64±2.93 SD, 95% CI from 82.16 to 83.12,	20.72	1.69	33.47	-148.08	<0.001	5.06	1.31	6.52	-46.61	<0.001
6.	7 min	80 to 90% (mean of 86.09±2.31SD , 95%CI from 61.38 to 62.46	24.17	1.97	39.04	-148.04	<0.001	3.45	1.41	4.17	-29.47	<0.001
7.	10 min	86 to 95% (mean of 90.72±2.45 SD, 95% CI from 90.82 to 91.13	28.81	1.79	46.52	-193.96	<0.001	4.63	1.51	5.61	-37.00	<0.001

The SpO2 ranged from 57 to 68% (mean of 61.92±3.30 SD,95% CI 61.38 to 62.46), 63 to 73%(67.18±3.34 (SD, 95% CI 66.63 to 67.73), 66 to 78% (mean 72.19±3.20 SD, 95% CI 71.66 to 72.71), 73 to 85% (mean 77.56±3.18 SD, 95% CI 77.06 to 78.11), 76 to 88% (mean 82.64±2.93 SD, 95% CI from 82.16 to 83.12, 80 to 90% (mean 86.09±2.31SD, 95%CI from 61.38 to 62.46, 86 to 95% (mean 90.72±2.45 SD, 95% CI from 90.82 to 91.13), at 1,2,3,4,5,7 and 10min respectively.

As compared to baseline (1 min) mean change in SpO2 and correspondingly a % increment in mean SpO2 ranged from 5.26±1.20% to 28.81 and 8.50 to 46.52% respectively. At all the time intervals, mean change from baseline was statistically significant (p<0.001).On comparing the change in oxygen saturation from the immediate preceding interval mean change ranged from 3.45±1.41% (5 to 7 min) to 5.40±1.40% (3 to 4 min) respectively. Maximum and minimum % increase from preceding interval was 8.50% (from baseline to 2 min) and at 4.17% (5 to 7 min). For all the time intervals, the change from immediate preceding time interval was significant statistically (p<0.001)

Evaluation of Change in SpO2 Levels at different time intervals upto 10 minutes of neonatal life (Full term neonates) (n=93)

Table no-2

SN	TIME INTERVAL	SpO2	Change from baseline (1 min)					Change from immediate preceding measurement				
			Mean	SD	% Change from baseline	't'	'p'	Mean	SD	% Change from baseline	't'	'p'
1.	1 min	58 to 67% (mean of 63.52±3.04 SD, 95% CI from 62.89 to 64.14)										
2.	2min	64 to 73% (mean 68.73±3.21 SD, 95% CI from 68.07 to 69.39)	5.22	1.23	8.21	-40.81	<0.001	5.22	1.23	8.21	-40.81	<0.001
3.	3min	68 to 78% (mean 73.68±2.94 SD, 95% CI from 73.07 to 74.28)	10.16	1.38	16.00	-71.14	<0.001	4.95	1.19	7.20	-40.01	<0.001
4.	4min	73 to 85% (mean 78.95±3.12 SD, 95%CI from 78.30 to 79.59),	15.43	1.55	24.29	-96.05	<0.001	5.27	1.35	7.15	-37.57	<0.001
5.	5min	78 to 88% (mean 78±2.89 SD, 95%CI from 83.19 to 84.38	20.27	1.48	31.91	-131.82	<0.001	4.84	1.19	6.13	-39.17	<0.001
6.	7min	73 to 85% (mean 78.95±3.12 SD, 95%CI from 78.30 to 79.59),	23.43	1.64	36.89	-137.96	<0.001	3.16	1.26	3.77	-24.15	<0.001
7.	10min	87 to 95% (mean 91.94±2.12 SD, 95% CI from 91.50 to 92.37)	28.42	1.85	44.74	-148.20	<0.001	4.99	1.45	5.95	-33.22	<0.001

Paired 't'-test

In case of term newborn, At 1,2,3,4,5,7 and 10 min, SpO2 ranged from 58 to 67% (mean of 63.52±3.04 SD, 95% CI from 62.89 to 64.14),64 to 73%(mean of 68.73±3.21 SD, 95% CI from 68.07 to 69.39), 68 to 78% (mean of 73.68±2.94 SD, 95% CI from 73.07 to 74.28), 73 to 85%(mean of 78.95±3.12 SD, 95%CI from 78.30 to 79.59),78 to 88% (meanof 83.78±2.89 SD, 95%CI from 83.19 to 84.38), 81 to 90%(mean of 86.95±2.27 SD, 95% CI from 86.48 to 87.41), 87 to 95%(mean of 91.94±2.12 SD, 95% CI from 91.50 to 92.37).

As compared to baseline (1 min) mean change in SpO2 and % increment in mean SpO2 ranged from 5.22±1.23% to 28.42±1.85% and 8.21 to 44.74% respectively. At all the time intervals, mean change from baseline was significant statistically (p<0.001).On comparing the change in oxygen saturation from the immediate preceding interval mean change ranged from 3.16±1.26% (5 to 7 min) to 5.27±1.35% (3 to 4 min) respectively. Maximum and minimum % increase from preceding interval was 8.21% (from baseline to 2 min) and 3.77% (5 to 7 min). For all the time intervals, the change from immediate preceding time interval was significant statistically (p<0.001).

Evaluation of Change in SpO2 Levels at different time intervals upto 10 minutes of neonatal life (Preterm neonates) (n=52)

Table no-3

SN	Time interval	SPO2	Change from baseline (1 min)					Change from immediate preceding measurement				
			Mean	SD	% Change from baseline	't'	'p'	Mean	SD	% Change from baseline	't'	'p'
1.	1 min	57 to 61% (mean 59.06±1.04 SD, 95% CI from 58.77 to 59.35)										
2.	2 min	63 to 66% (mean 64.40±0.82 SD, 95%CI from 64.17 to 64.63)	5.35	1.15	9.05	-33.44	<0.001	5.35	1.15	9.05	-33.44	<0.001
3.	3 min	66 to 74% (mean 69.52±1.41 SD, 95% CI from 69.13 to 69.93,	10.46	1.43	17.71	-52.60	<0.001	5.12	1.52	7.94	-24.32	<0.001
4.	4 min	73 to 80% (mean of 75.15±1.26 SD, 95% CI from 74.80 to 75.50)	16.10	1.46	27.25	-79.57	<0.001	5.63	1.46	8.11	-27.91	<0.001
5.	5 min	76 to 85% (mean 80.60±1.56 SD, 95% CI from 80.16 to 81.03)	21.54	1.73	36.47	-89.69	<0.001	5.44	1.42	7.24	-27.64	<0.001
6.	7 min	80 to 87%(mean 84.56±1.45 SD, 95% CI from 84.15 to 84.96)	25.50	1.81	43.18	-101.62	<0.001	3.96	1.52	4.92	-18.79	<0.001
7.	10 min	86 to 92% (mean 88.56±1.18 SD,95%CI from 88.23 to 88.39).	29.50	1.45	49.95	-146.86	<0.001	4.00	1.41	4.96	-20.40	<0.001

Paired 't'-test

At 1,2,3,4,5,7,10min SpO2 ranged from 57 to 61% (mean 59.06±1.04 SD , 95% CI from 58.77 to 59.35), 63 to 66%(mean 64.40±0.82 SD, 95%CI from 64.17 to 64.63), 66 to 74% (mean 69.52±1.41 SD, 95% CI from 69.13 to 69.93, 73 to 80% (mean 75.15±1.26 SD, 95% CI from 74.80 to 75.50),76 to 85% (mean 80.60±1.56 SD, 95% CI from 80.16 to 81.03), 80 to 87%(mean 84.56±1.45 SD, 95% CI from 84.15 to 84.96),86 to 92% (mean 88.56±1.18 SD, 95% CI from 88.23 to 88.39).

As compared to baseline (1 min) mean change in SpO2 and correspondingly a % increment in SpO2 ranged from 5.35±1.15% to 29.50±1.45% and 9.05 to 49.95% respectively. At all the time intervals, mean change from baseline was significant statistically (p<0.001).On comparing the change in oxygen saturation from the immediate preceding interval mean change ranged from 3.96±1.52% (5 to 7 min) to 5.63±1.46% (3 to 4 min) respectively. Maximum and minimum % increase from preceding interval was 9.05% (from baseline to 2 min) and 4.92% (5 to 7 min) respectively. For all the time intervals, the change from immediate preceding time interval was significant statistically (p<0.001).Average per min increase in oxygen saturation upto 10 min of life was 2.95%. The average per min increase in first 5 min and next 5 min was 4.31% and1.59% per min respectively.

FACTORS AFFECTING SPO2
a) Gestational Age

Table no. 4: Comparison of Mean SpO2 upto 10 minutes of life between Full term and Preterm Neonates

SN	Time interval	Full term neonates (n=93)		Preterm neonates (n=52)		Significance of difference	
		Mean	SD	Mean	SD	't'	'p'
1.	1 min	63.52	3.04	59.06	1.04	12.862	<0.001
2.	2 min	68.73	3.21	64.40	0.82	12.308	<0.001
3.	3 min	73.68	2.94	69.52	1.41	11.482	<0.001
4.	4 min	78.95	3.12	75.15	1.26	10.312	<0.001
5.	5 min	83.78	2.89	80.60	1.56	8.618	<0.001
6.	7 min	86.95	2.27	84.56	1.45	7.728	<0.001
7.	10 min	91.94	2.12	88.56	1.18	12.349	<0.001

At baseline, mean oxygen saturation was 63.52±3.04% for full term and 59.06±1.04% for preterm neonates, thus showing a mean difference of 4.46% between two groups. With passage of time, mean oxygen saturation levels in both the groups showed an incremental trend to reach at 91.94±2.12% and 88.56±1.18% respectively in full term and preterm groups at 10 min, and thus showing a mean difference of 3.38%. The mean difference between two groups was maximum at baseline (4.46%) and minimum at 7 min (2.39%). Statistically, the difference between two groups was significant at all the follow up intervals (p<0.001).

b) **Mode of Delivery**

Table no.5: Comparison of Mean SpO2 upto 10 minutes of life between neonates born through vaginal and caesarean deliveries.

SN	Time interval	Vaginal		LSCS		Significance of difference	
		Mean	SD	Mean	SD	't'	'p'
Overall		(n=93)		(n=52)			
1.	1 min	63.09	3.43	59.83	1.62	7.753	<0.001
2.	2 min	68.53	3.38	64.77	1.28	9.568	<0.001
3.	3 min	73.33	3.29	70.13	1.62	7.821	<0.001
4.	4 min	78.77	3.22	75.46	1.63	8.214	<0.001
5.	5 min	83.72	2.96	80.71	1.58	7.990	<0.001
6.	7 min	87.00	2.24	84.46	1.35	8.507	<0.001
7.	10 min	91.45	2.65	89.42	1.26	6.236	<0.001

On overall as well as in full term deliveries, mean oxygen saturation was significantly higher in neonates born through vaginal route as compared to that of neonates born through caesarean route at all the time intervals (p<0.001). However, in preterm deliveries, at any of the time intervals, the difference between two modes of deliveries were not significant statistically (p>0.05).

C) OTHER FACTORS-On overall assessment, with increasing birth weight an increase in mean SpO2 of neonates was observed which was also significant statistically upto 4 min of life and thereafter at 10 min of life. However, on evaluating the same in two groups separately, the association between birth weight and SpO2 was not significant statistically. GENDER AND HEART RATE ,overall as well as in both full term and preterm deliveries, there was no significant difference in mean SpO2 values between two groups at any of the evaluation periods.

DISCUSSION

Post-natal changes in environment affect the oxygen saturation of babies. It is reported that initial few minutes in neonatal life show a qualitative as well as quantitative change in neonatal SpO2. This study is an attempt to provide normative range for oxygen saturation during the initial ten minutes of life.

On analysing the total sample the increase in mean % SpO2 IN FIRST TEN MINS is by 46.52%. Average per min increase in SpO2 upto 10 min of life was 2.88%.The average per min increase in the first 5 mins and next 5 mins was 4.14% and1.62% per min respectively. These results are in agreement with the findings of a number of researchers who have shown that increment in SpO2 shows a steep increase followed by a stable phase. The study by Toth *et al.* (2002)1[1] showed that SpO2 at 2 mins was 73% and reaches to >95% at 12 min. Kamlin *et al.* (2006)[16] showed the increase in mean SpO2 between 1 min and 5 minute of 42.8% and per min % increase was nearly double at 8.6% v/s 4.14%. The median SpO2 in the study by Rabi *et al*[17] was 87% at 5 min, which is close to the normative range for Indian neonates at 82.16 to 83.12%. The SpO2 is affected by geographic location and altitude from sea level[18,19] justifies the differences in studies at different locations and hence once again stress the need for population specific normative range.

Table no,6:Normative Range of Full Term Neonates comparison with different studies

Time (Mins)	My study	Toth et al	Kamlin et al	Lu et al
1	58-63%	-	58-63%	67%
2	64-73%	44-95%	-	-
3	68-78%	-	-	-
4	73-85%	-	-	89%
5	78-88%	-	79-91%	>90%
7	81-90%	-	-	-
10	87-95%	-	-	-

Study by Shah et al[20] as well as findings of present study indicated a significant difference in SpO2 levels of preterm and full term neonates, thus underscoring the need for separate normative ranges for full term and preterm neonates.

The normative range of oxygen saturation among full term neonates was 62.89-92.47% between 1 min and 10 min of life, %SpO2 increased by 44.74% from a mean value of 63.52±3.04% to 91.94±2.12%. Average per min increase in SpO2 upto 10 min of life was 2.84%. The average per min increase in first 5 mins and next 5 mins was4.05% and 1.63% per min respectively. The trend of increase and pattern of change during first 5 minutes and at subsequent intervals is similar to that reported in literature as cited in Toth et al, Kamlin et al, Lu et al. However, when compared with other studies in full term neonates these normative ranges come closure than the common normative range for all neonates. For example, the median oxygen saturation value reported by Rabi *et al.*[17] in healthy term neonates was 87%, which is more close to corresponding normative range value of term neonates deduced in present study (83.19-84.38%).

The findings of present study showed that neither common normative range nor normative range specific for full term showed achievement of 90% oxygen saturation at 5 minutes. This finding is in agreement with the observations of Mariani *et al.* (2007)15 who found that in healthy newly born infants, oxygen saturation rises slowly and does not usually reach 90% in the first 5 minutes of life. However, contrary to findings of present study, Lu *et al.* (2014)[21] reported achievement of oxygen saturation >90% at the 5th minute. This difference in pathway of oxygen saturation normalization might be dependent on geographical location.

Table no,7:Normative Range of Preterm Neonates comparison of studies

Mins	My study	Dawson et al	Nuntnarumit et al
1	57-61%	-	-
2	63-66%	84%	72-92%
3	66-74%	-	75-94%
4	73-80%	-	80-94%
5	76-85%	92%	79-95%
6	-	-	85-97%
7	80-87%	-	-
10	86-92%	-	-

The normative range for SpO2 in preterm neonates from 1min to 10 min of life was 58.77-88.89% .The average per min increase in SpO2 upto 10 min of life was 2.95%. The average per min increase in first 5 min and next 5 min was 4.31% and 1.59%per min respectively. In present study, mean SpO2 levels were significantly higher in full term neonates as compared to preterm neonates throughout the evaluation period. An evaluation of the pattern of change in oxygen saturation shows that the preterm neonates generally follow the same trend of post-natal change in oxygen saturation as does the full term neonates and the differences in mean oxygen saturation levels of preterm and full term neonates were mainly due to difference in baseline values.

Similar to trend of change of oxygen saturation as observed in present study, Nuntnarumit *et al.* (2010)[22] showed incremental trend in oxygen saturation of preterm neonates, however, in their study 95% oxygen saturation was achieved at 6 min itself. However, Shah *et al.* (2014)[20] in their study showed that in preterm neonates oxygen saturation are always <90% till 10th min of their birth. Study by Dawson et al also suggests achieving SpO2 >90% at 5mins.

Mean SpO2 levels were significantly higher in neonates born through vaginal delivery as compared to those born through cesarean delivery. However, amongst preterm neonates this relationship was not significant statistically. In the present study, mean SpO2 of cesarean delivery neonates was almost 4% less than that of infants born through vaginal delivery. No significant association between SpO2 and heart rate or gender of neonate was observed in overall assessment or for full term and preterm groups separately. With increasing birth weight, a significant increase in SpO2 was observed on overall assessment.

CONCLUSION

Mean oxygen saturation levels were significantly higher in full term neonates as compared to preterm neonates throughout the evaluation period. Mean oxygen saturation levels were significantly higher in neonates born through vaginal delivery as compared to those born through cesarean delivery neonates throughout the evaluation period for overall assessment and amongst full term neonates. However, amongst preterm neonates this relationship was not significant statistically. Gender and heart rate has no correlation with SpO_2

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