Original Research Article

Comparison of pulse oximetry and colour: a better index of oxygenation in neonatal resuscitation

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ABSTRACT

Background: Colour is an unreliable indicator of tissue oxygenation in the first few minutes of life. Little data is available about the progression of SpO₂ in the new-borns delivered by normal vaginal route and caesarean section. So this study was conducted. The objectives of this study were to compare the new-born's colour and oxygen saturation readings as an index of oxygenation and to find a more reliable one, and to compare the oxygen saturation profiles of the new-borns delivered by normal vaginal route and caesarean section.

Methods: This was a prospective observational study conducted over a period of one year in a tertiary care hospital on 500 newborns between 28-42 weeks, requiring routine care. Simultaneous assessment of colour and oxygen saturation readings was done at 30 second intervals after birth till 10 minutes of life.

Results: No significant difference has been found in the median SpO₂ values of the new-borns requiring routine care that were pink and cyanosed since birth ($p \geq 0.05$). About 5.30 minutes required for most of the cyanosed new-borns to become pink ($p \geq 0.05$). Mean time $\pm$ SD required for cyanosed new-born for getting pink was 1.96 ± 1.33 minutes. Oxygen saturation rises slowly in new-borns delivered by caesarean section as compared to those delivered vaginally, especially in the first few minutes of life and more in preterm than term new-borns.

Conclusions: Unnecessary use of oxygen can be avoided by taking into account pulse oximetry. Separate sets of reference SpO₂ should be used for new-borns delivered by normal vaginal route and caesarean section.

Keywords: Caesarean section, Colour, Cyanosis, New-born SPO₂, Normal vaginal delivery, Oxygen saturation

INTRODUCTION

Assessing the oxygenation status of the newborns at birth and immediately after that has always been a difficult task for paediatricians. Traditionally it has been done with the assessment of the colour of the newborn at birth and further, the requirement of oxygen was also detected on the basis of colour (pink or blue). But there has always been a disagreement about the colour of the newborn and substantial inter-observer and intra-observer variations exist about the colour and the reference SpO₂ at which the newborn is considered pink or cyanosed (blue).¹

The American Academy of Paediatrics (AAP) and American Heart Association (AHA) revised the guidelines of neonatal resuscitation in 2010. The concept of pulse oximetry in neonatal resuscitation was introduced in 2010 by the American Academy of paediatrics (AAP) and the International Liaison Committee on Resuscitation (ILCOR) in place of visual assessment of colour for both term and preterm newborns. Also, the reference range of oxygen saturation from to 10 minutes of life has been provided in the algorithm of neonatal resuscitation, calculated on the basis of existing data on oxygen saturation in healthy term newborns in the first few minutes of life.^{2,3}

Pulse oximetry provides rapid, continuous and accurate information of oxygenation in the form of SpO₂. Fetal SpO₂ is 50-60%, dropping to an intrapartum mean of 40-50%. Hence it is normal for a healthy newborn to be cyanosed in the first few minutes of life after birth.^{4,5}

Administering 100% oxygen to a spontaneously breathing newborn based only on visual assessment of colour may be unnecessarily invasive and may lead to potentially harmful hyperoxia.⁵ Moreover, newborns in the Indian set-up have a comparative darker complexion, which further creates a problem in the colour assessment. Also, little data is available about the progression of SpO₂ in the newborns delivered by normal vaginal route or caesarean section and we use the same set of reference SpO₂ for these newborns irrespective of their mode of delivery and gestational age status.

Thus to find out a better index of oxygenation, this study was conducted, hypothesizing that pulse oximetry provides a better and more reliable way of assessing the oxygenation status than colour in both term and preterm newborns. In addition, to find out the effect of mode of delivery and gestational age on the oxygen saturation profiles of the newborns, the oxygen saturation readings of the newborns delivered by normal vaginal route and caesarean section were also compared separately for term and preterm newborns.

METHODS

After taking the ethical approval from the institutional ethical committee, this prospective observational study was conducted in the new-born resuscitation corner of the labour room and operation theatre of a level-3 special care new-born unit (SNCU) of a tertiary level government medical college hospital. The process was conducted in the presence of a resident trained in neonatal resuscitation and the observer was not involved in the process of resuscitation. This study was conducted over a period of one year. A sample size of 357 newborns was obtained with 95% confidence interval. But a sample size of 500 newborns was taken in order to have a larger sample size.

Inclusion criteria

New-borns delivered by either normal vaginal route or caesarean section between a gestational age of 28 weeks to 42 weeks (by New Ballard scoring), requiring routine care were included in this study.⁶

Exclusion criteria

New-borns with major congenital anomalies, requiring supplemental oxygen, medical intervention or resuscitation of any kind, extremely low birth weight (ELBW) and those born with meconium stained amniotic fluid were excluded. New-borns in which we failed to apply probes or probe was detached were also excluded.

Procedure

A written informed consent was taken from the relatives in all cases before delivery. All the enrolled new-borns were divided into two groups

- As per gestational age into term (≥ 37 weeks to ≤ 42 weeks) and preterm (≥ 28 weeks to < 37 weeks).
- As per mode of delivery into normal vaginal delivery group and caesarean section group.

In the present study, Masimo rad 5 pulse oximeter with signal extraction technology (SET) was used, which provides reliable readings even in low perfusion states and with patient movements.^{7,8} The pulse oximeter was set to acquire data with maximal sensitivity and there was an inbuilt recording of SpO₂ and heart rate at every 2 second interval in the form of trend chart.

The umbilical cord was clamped immediately after the birth of the new-born and the baby was taken in a pre-warmed towel on a resuscitation trolley under a radiant warmer. Simultaneously, a stopwatch was started and the probe of the pulse oximeter (neonatal wristband probe) was attached to the new-born's right hand's wrist and then connected to the pulse oximeter, keeping in mind the method and precautions as described by the American Academy of Pediatrics.^{2,3,9} Simultaneously, the colour of the new-born's lips was also noted. This simultaneous assessment of both oxygen saturation readings and colour of the new-born was done at every 30 second interval till 10 minutes of life. Similarly, the SpO₂ values of the newborns delivered by normal vaginal route and caesarean section were compared from birth at every 30 second interval till 10 minutes of life separately for term and preterm newborns.

Data for each new-born was collected manually at every 30 second interval as well as from the trend chart stored within the pulse oximeter. Also, time to record the first data of SpO₂ after applying the probe was also recorded in each case. Individual readings of SpO₂, colour and time were then entered into separate excel spread sheets which were then merged and analysed with Minitab software. Z-test was applied to determine the mean time for getting pink, mean time for recording first data of SpO₂ and mean time to reach $\geq 90\%$ saturation in term and preterm newborns. SpO₂ data of term newborns delivered by normal vaginal route and caesarean section and preterm newborns delivered by normal vaginal route and caesarean section were compared separately from birth till 10 minutes of life at every 30 second intervals and p values were calculated.

RESULTS

A total of 500 newborns were enrolled in this study, out of which 81 were excluded. So 419 newborns were taken in this study. A total of 301 term newborns and 118 preterm newborns were enrolled with a mean (SD)

gestational age of 39.02 ± 0.08 weeks for term newborns and 34.93 ± 1.32 weeks for preterm newborns. The mean (SD) birth weight for term newborns was 2.621 ± 0.010 kg and for preterm newborns was 1.98 ± 0.08 kg. 59.18% of

newborns were delivered by normal vaginal route and 40.81% by caesarean section. The characteristics of the newborns are presented in Table 1.

Table 1: Characteristics of new-borns.

New-born's characteristics	Routine care		Total
	No.	%	
Birth weight			
<2500 gm	255	60.85%	419
≥ 2500 gm	264	63.00%	
Gestation			
28-36.6 weeks	118	28.16	419
37-42 weeks	301	71.83	
Mode of delivery			
NVD	248	59.18	419
LSCS	171	40.81	
Colour at the time of birth			
Pink	131	31.26	419
Blue	288	68.73	

In this study, on simultaneously assessing the colour and oxygen saturation readings of the preterm and term newborns (Table 2 and 3), it has been found that there was statistically no significant difference in the median SpO₂ values of the newborns that were pink since birth and the newborns that were blue (cyanosed).

It took about 5.30 minutes for most of the newborns that were cyanosed to become pink in both the term and preterm group and the p value was found to be insignificant ($p \geq 0.05$) at most time intervals and

especially in the first 2-3 minutes of life where it is critical to decide whether oxygen has to be given to the newborn or not. 2 tailed unpaired t-test was done to compare the median SpO₂ values of the newborns that were pink and the newborns that were blue in both the term and preterm group and it gave a score of 0.7596 and 0.8806 respectively. Mean time $\pm$ SD required for cyanosed newborn for getting pink was 1.96 ± 1.33 minutes with a standard error of mean of 0.079. Mean time $\pm$ SD of 0.987 ± 0.549 minutes with a standard error of mean of 0.035 was required to record the first data of SpO₂ in all new-borns.

Table 2: Correlation of colour and SpO₂ in preterm new-borns requiring routine care.

Time after birth	Preterm (median SpO ₂ value)				
	Pink	Median SpO ₂	Blue	Median SpO ₂	P value
At Birth	46	43.5	72	40	0.269
30 sec	60	46	58	50	0.072
1 min	81	58	37	59	0.312
1 min 30sec	102	62	16	62	0.625
2 min	108	65	10	65	0.471
2 min 30sec	112	67	06	68	0.896
3 min	112	70	06	69	0.184
3 min 30sec	112	73	06	71	0.019
4 min	112	75	06	73	0.011
4 min 30sec	112	77	06	74	0.0056
5 min	113	79	05	77.5	0.137
5 min 30sec	115	83	03	81	0.374

Table 3: Correlation of colour and SpO₂ in term new-borns requiring routine care.

Time after birth	Term (median SPO ₂ value)				
	Pink	Median SpO ₂	Blue	Median SpO ₂	P value
At Birth	86	48	215	46	0.707
30 sec	112	50	189	54	0.0654
1 min	148	59	153	59	0.174
1 min 30 sec	175	63	126	62	0.001
2 min	213	65	88	64	0.006
2 min 30 sec	247	68	54	68	0.729
3 min	272	71	29	70	0.653
3 min 30 sec	282	74	19	72	0.84
4 min	283	76	18	73.5	0.062
4 min 30 sec	284	79	17	75	0.008
5 min	286	83	15	80	0.112
5 min 30 sec	289	85	12	82	0.057

Table 4 and Figure 1 and 2 illustrates the comparison of median SpO₂ values of term and preterm newborns delivered by vaginal and caesarean route which also shows that the SpO₂ values rises slowly in newborns delivered by caesarean route than normal vaginal route though both acquire $\geq 90\%$ saturation within 10 minutes of life. Further, the SpO₂ values of preterm newborns delivered by caesarean section were found on the lower side as compared to term newborns delivered by caesarean section, especially in the first few minutes of life.

DISCUSSION

Assessment of colour in the new-borns during neonatal resuscitation has always been a matter of debate. In this study, on simultaneously assessing the colour and recording the oxygen saturation values, this fact has been elucidated that it may be possible for a newborn to be cyanosed in the initial few minutes of life after birth, providing the oxygen saturation values are coming within the reference range.

Donnell et al used the video recordings of the newborns to find out if the clinicians agreed whether infants were pink and the oxygen saturation at which the infants first looked pink and concluded that there was substantial variation in the perception of newborn infant's colour among the neonatal staff and there was disagreement between observers about the colour of the same infant and the SpO₂ at which they perceive infants to be pink varied widely.¹

According to the American Academy of Pediatrics and American Heart Association 2010 guidelines, there is a large body of evidence that blood oxygen levels in uncompromised babies generally do not reach the extra uterine values until approximately 10 minutes following birth. Oxyhemoglobin saturation may normally remain in

the 70-80% range for several minutes, thus resulting in the appearance of cyanosis.^{2,3} Many studies also support the fact that it may take up to 10 minutes for oxyhemoglobin saturation to reach up to 90%. Dawson et al found that during the first few minutes of life, oxygen saturation increases from intra-partum levels of 30-40%. Thus clinical assessment of skin colour during neonatal resuscitation is unreliable.⁷ Sucheta et al also support the assertion that it may take up to 10 minutes for the oxyhemoglobin to reach up to a saturation level of 90% and only visual interpretation of cyanosis without doing pulse oximetry could lead to adverse outcomes in the baby. In their study, it took 7.4 minutes to reach a median preductal SpO₂ of 90%.⁸

Figure 1: Progression of SpO₂ in term new-borns delivered by normal vaginal route and caesarean section.

Similarly, several other studies from various parts of the world have reported time between 8-15 minutes to reach SpO₂ $\geq 90\%$. In the present study, mean time of 8.35 ± 1.16 min (IQR of 7.3 to 9.3 min) was required for term newborns and 9.32 ± 0.59 min (IQR of 9-10 min) for preterm newborns to reach the SpO₂ $\geq 90\%$. Thus preterm newborns took longer time to acquire $>90\%$ saturation status than term newborns and there are more

chances for them to be cyanosed for longer duration than term newborns.

Figure 2: Progression of SpO₂ in preterm new-borns delivered by normal vaginal route and caesarean section.

Many other studies came out with the same result like Dawson et al found that it took a median of 7.9 minutes (IQR: 5-10 minutes) to reach SpO₂ of $\geq 90\%$ and also

showed that preterm newborns took longer than term newborns. The median SpO₂ at 5 minutes for preterm newborns was 86% compared to 92% for term newborns ($p \leq 0.001$).⁷ Thus administering 100% oxygen to a spontaneously breathing newborn based only on visual assessment of cyanosis may be unnecessarily invasive and lead to potentially harmful hyperoxia. Mean time $\pm$ SD of recording first data of SpO₂ in the present study was 0.987 ± 0.549 minutes with a standard error of mean of 0.035, which is supported by other studies, like in a study conducted by Rabi et al in 2004-2005 on infants ≥ 35 weeks gestation not requiring supplemental oxygen over a period of 10 minutes after birth, it took a median time of about 82 seconds (IQR 30-140 seconds) to record a stable SpO₂ reading after probe placement.¹⁰ Similarly, in a study conducted by Kamlin and O'Donnell et al to find out the oxygen saturation in healthy infants immediately after birth, SpO₂ readings were obtained within 60 seconds of age in 92 out of 175 (53%) infants.¹¹ Also, it took longer for preterm newborns to record the first data of SpO₂. Thus if we go by colour, preterm new-borns are more likely to be cyanosed in the initial few minutes of life and we erroneously flood them with oxygen which is actually not required.

Table 4: Influence of mode of delivery on the median SpO₂ in term and preterm new-borns.

Time after birth	Term NVD (Q1-Q3)	Term LSCS (Q1-Q3)	P value	Preterm NVD (Q1-Q3)	Preterm LSCS (Q1-Q3)	P value
Birth	48 (46-50.5)	46.5 (46-47.75)	$p > 0.05$	50 (46-55.5)	41 (40-45)	$p < 0.01$
1 min	60 (59-62)	58 (57-59)	$p < 0.01$	59 (58-60)	58 (57-59)	$p < 0.01$
2 min	67 (65-68)	63 (62-64)	$p < 0.01$	65 (64-66)	62 (60-62)	$p < 0.01$
3 min	72 (70-73.25)	69 (66-70)	$p < 0.01$	70 (69-71)	70 (69-71)	$p > 0.05$
4 min	76 (75-78)	74 (69-77)	$p < 0.01$	75 (73-77)	74.5 (73-75)	$p > 0.05$
5 min	82.5 (80-84)	83 (74-86)	$p > 0.05$	80 (78-82)	78 (77-80)	$p < 0.05$
6 min	87 (85-89)	89 (79.75-90)	$p > 0.05$	85.5 (85-86)	85 (80-87)	$p > 0.05$
7 min	91 (89-93)	92 (84-94)	$p > 0.05$	88 (87-89)	85.5 (84-88.25)	$p < 0.05$
8 min	94 (92-95)	89.5 (87-95)	$p < 0.01$	91 (90-93)	89 (88-93)	$p < 0.05$
9 min	96 (95-97)	93 (91-97)	$p < 0.01$	96 (95-97)	94 (92-95)	$P < 0.01$
10 min	98 (97-99)	97 (96-97)	$p < 0.01$	98 (97.25-99)	97 (95-98)	$p < 0.01$

Also in the present study, there was a delay in the rise of SpO₂ in newborns delivered by caesarean section as compared to newborns delivered vaginally especially in the first few minutes of life in both term and preterm group ($p \leq 0.01$). Both groups acquired $\geq 90\%$ SpO₂ within the 10 minute period. Further the SpO₂ values of preterm newborns delivered by caesarean section were found to be on the lower side as compared to the term newborns delivered by caesarean section. This fact is supported by other studies where the mode of delivery significantly affected the progression of SpO₂. Rabi et al also concluded that newborns delivered by caesarean section had a 3% lower SpO₂ than newborns delivered vaginally.¹⁰ Dawson et al also found that infants born through caesarean section had lower SpO₂ measurements

than those delivered vaginally in the first 5 minutes after birth.⁷ This fact is also supported by Harris et al in their study.¹² On the other hand, there are also some studies which support the fact that the mode of delivery does not affect the SpO₂ progression.^{13,14} The present study was conducted with a new generation pulse oximeter with a neonatal probe keeping in mind the guidelines provided by the American Academy of Paediatrics to reduce the motion artefacts and other pitfalls. All the readings of colour and SpO₂ were taken by a single observer to minimize inter-observer variations.

This study hypothesized that pulse oximetry is a better index of oxygenation than visual assessment of colour and it has been found that definitely pulse oximetry gives

a better assessment of oxygenation status in both term and preterm newborns. The unreliability and inter-observer variation which was there with the use of colour has declined to a great extent with the use of pulse oximetry. If pulse oximetry would not have been used, these cyanosed newborns might be erroneously given oxygen. This is particularly useful in Indian set-up because of a comparative darker skin tone of newborns as compared to the western world and also it is less likely to be affected by parameters like meconium staining and polycythemia which can affect the colour assessment.

Also, as there is variation in the progression of SpO₂ of newborns delivered by normal vaginal route and caesarean section, we need to have separate sets of reference SpO₂ values, based on their gestational age and mode of delivery, so that we can apply for them separately. Also, some more studies with larger sample size need to be done to have more conclusive results. Thus, the present study emphasis on the routine use of pulse oximetry in the delivery room as per the recommendations of ILCOR with the simultaneous assessment of colour, so that our newborns can be saved from the detrimental effects of excess oxygen.

CONCLUSION

Pulse oximetry is a simple, handy, noninvasive, fast, continuous and accurate way of assessing the oxygen saturation. It gives a better index of oxygenation than colour in newborns in Indian set-up. Separate sets of reference SpO₂ should be used for newborns delivered by normal vaginal route and caesarean section. As pulse oximeter takes some time to record the SpO₂ data, the need of the time states that some more sophisticated ways should be devised to have an assessment of newborn oxygenation status as early as possible after birth.

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