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Research Article

"Comparison of Heart Rate between Preterm and Term Infants"

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Abstract

Introduction: The transition from fetus to newborn is a complex physiological process. There is growing interest in the use of pulse oxymetry to assess the condition of infants immediately after birth. Heart rate, measured by counting the heart beats/minute, is a net effect of the decelerating influence of the vagal (parasympathetic) fibers, and the accelerating influence of the sympathetic fibers on the inherent rhythmicity of the heart's sinoatrial node.

Objective: To assess the Comparison of heart rate between preterm and term infants.

Material and Methods: A cross sectional study was carried out to see oxygen saturation immediately after birth and to describe changes in heart rate immediately after birth. A total 317 patients were selected according to selection criteria. In the delivery room, Department of obstetrics and gynecology, 250 Beded General Hospital, Noakhali, Bangladesh from October 2017 to March 2018.

Results: A total 317 neonate were selected according to selection criteria. Among the study subjects more than half were male (57.1%). Rests were female (42.9%). The mode of delivery was mostly LUCS (96.6%). Only 5.4% cases it was NVD. Average gestational age of the study subjects was 37.47 ± 1.16 (SD) with the range of 34 - 40. On the other hand average birth weight was 2.88±0.46 (SD) with the minimum birth weight 2.0 kg and maximum weight 4.2 kg. More than three forth of the study subjects had motion artifact (77.0%) and in 48.9% cases vernix was present. Among the study subjects high ambient light present in 3.5% cases and low perfusion present in 1.3% cases. Acrocyanosis was present in 2.5% cases. Showed that differences of heart rate in two minutes after delivery were statistically significant. The median values were more in vaginal birth from 1 to 9 minutes. But median heart rate was more in 10 minutes in caesarian birth baby. But these differences were not statisticaly significant. Illustrates the median (IQR) heart rate from one to ten min for preterm versus term births. At one to three minutes and at five minutes after birth preterm infants had significantly lower SpO2 measurements. From six to 10 minutes after birth and four minutes after birth there was no significant difference between SpO2 measurements for mode of delivery. Paired sample t test showed that average heart rate was more in 1 minute [155.06 ± 13.12 (SD)] than in 5 minute [153.43 ± 14.13 (SD)] and statistically this differences were significant (t = 2.149, p = 0.032). Pearson correlation showed high positive correlation i.e., heart rate in 5 minutes was less than heart rate in 1 minute (p = 0.000) and correlation co-efficient r = 0.509. Correlation was significant at the 0.01 level.

Conclusion: Heart rate can be low in the first minutes after birth in infants with good respiratory effort and muscle tone. The main focus of this thesis was to define the reference range for measurements of oxygen saturation and heart rate in the first minutes after

birth from a large cohort of infants not receiving interventions in the delivery room. My findings add to the body of knowledge regarding the change in oxygen saturation and heart rate in the first minutes after birth

Keywords: *Heart Rate; Preterm; Term Infants; Pulse Oxymetry.*

Introduction

The transition from fetus to newborn is a complex physiological process. There is growing interest in the use of pulse oxymetry to assess the condition of infants immediately after birth [1]. In the first day of life bidirectional shunting through ductus may occur and this is often proposed as an explanation for a poor SpO2. A healthy baby that is born full term should have oxygen saturations of 95 to 100 percent. Heart rate, measured by counting the heart beats/minute, is a net effect of the decelerating influence of the vagal (parasympathetic) fibers, and the accelerating influence of the sympathetic fibers on the inherent rhythmicity of the heart's sinoatrial node. Under resting conditions, the vagal effects vary with the respiratory cycle. During inspiration, vagal impulses reaching the heart decrease, producing an increase in heart rate; during expiration, they increase, producing a decrease in heart rate [2]. Pulse oxymetry if routinely used in intensive care, gives continuous accurate measures of Heart Rate and Oxygen Saturation. The majority of newborn infants make the transition from the intrauterine to extrauterine environment successfully; however, approximately 10% of newborn infants require assistance during this transition. Heart rate (HR) is the most important clinical indicator to evaluate the clinical status of a newborn [3,4]. Heart rate (HR) is the most important clinical indicator to evaluate the clinical status of a newborn. In algorithms for neonatal resuscitation published by the International Liaison Committee for Resuscitationp [3], European Resuscitation Council, [5] and Australian Resuscitation Council, [6] clinical assessment of an infant's colour (a measure of oxygenation) and heart rate are used as major action points. However, studies have shown that clinical assessment of colour during neonatal transition is unreliable [7,8]. O'Donnell8 showed that the oxygen saturation (SpO_2) at which observers perceived infants to be pink varied widely, ranging from 10 to 100%. Assessing colour is difficult and therefore is a poor proxy for tissue oxygenation during the first minutes of life. Kattwinkel, [9] suggested pulse oximetry may help achieve normoxia in the delivery room (DR). The American Heart Association, [10] suggest "administration of a variable concentration ofoxygen guided by pulse oximetry may improve the ability to achieve normoxia more quickly". "Normoxia" and an acceptable time to achieve this during neonatal transition have not been rigorously defined. Nevertheless, American experts Leone and Finer, [11] advocate a target "SpO_2 of 85 to 90% by three minutes after birth for all infants except in special circumstances"e.g. diaphragmatic hernia or cyanotic congenital heart disease. Pulse oximetry measures SpO_2 and heart rate (HR) continuously and non-invasively, without the need for calibration and correlates closely with arterial oxygen saturation [12]. As demographic data like(maturity, birth weight, gestational age, marenal age, maternal nutrition, socioeconomic status, mode of delivery, maternal problem during antinatal and perinatal period, number of gestation, foetal condition), genetic and environmental factor are different from other countries in Bangladesh. And there is no document of Oxygen Saturation and Heart Rate in Healthy Neonate immediately after Birth, in Bangladesh, during unassisted transition in the delivery room. No corresponding data are available in neonates in Bangladesh. So excessive administering of variable concentration oxygen leading to prolonged oxidative injury can be prevented. Nevertheless, rapid, reliable, and accurate HR detection and monitoring is a critical indicator of the clinical status of a newborn at delivery or in the NICU.

Material and Methods

A cross sectional study was carried out to see oxygen saturation immediately after birth and to describe changes in heart rate immediately after birth. A total 317 patients were selected according to selection criteria. In the delivery room, Department of Paediatrics,

250 Beded General Hospital, Noakhali, Bangladesh from October 2017 to March 2018. The parents were interviewed with a specific pre-designed and pre-tested questionnaire and some information were gathered by document review. All neonate both term and late preterm (> 34weeks) who would not be anticipated for resuscitation was included in Inclusion criteria. Main outcome variable were Oxygen Saturation and Heart Rate. Confounders were Birth weight, mode of delivery, maternal age, gestational age, motion artifact, presence of vernix, low perfusion, oedema, high ambient light, large infants, cracked/wrinkled skin, acrocyanosis.

Data collection and compliance

Incorporating this, prior to original data collection, a pre-test session was conducted among 10 cases in different hospital. Necessary modification was done before finalized the questionnaire. The researcher collected data through face-to-face interview. The interview was conducted anonymously as far possible. Before preceding the data collection, the detail of the study was explicitly explained to each eligible parents and verbal consents from the respondents were obtained. Hospital records were reviewed during data collection. Physical examination was done by physician.

Procedures of collecting data

- Demographic data was collected from Maternal and Neonates case records.
- A stop watch was started when the cord was clamped. All infants was dried and wrapped with warmed towels. The sensor was applied either to the palm of the right hand or to the right wrist and then connected to the oxymeter.
- All neonate was measured continuously for their Oxygen saturation and heart rate at 60 sec interval from birth for at least 10 min.
- When necessary, the sensor will remain attached even after the neonate was given to the parents. Results and conclusion was drawn after data collection and data analysis.

Statistical analysis

After collection all the data were checked and edited. Then data were entered into the computer with the help of software SPSS for windows programmed version 16.0. After frequency run, data were cleaned and frequencies were checked. An analysis plan was developed keeping in view with the objectives of the study. Cross tabulation was prepared and a comparison had been made between, Data was presented as means (SD) and analyzed with 2-tailed ***t*** tests when normally distributed. Median and interquartile ranges (IQR = Q3 - Q1) was provided and analyzed with nonparametric tests (2-tailed Mann-Whitney *U* test) when the distribution of the variable was skewed. The median SpO2 values (IQR) at 1,2,3,4 ...and 10 minutes, respectively was provided. Multivariate regression analysis was used to analyze potential confounding variable contributing to the primary end point (time taken for SPO2 > 90%). A *P* value of < .05 was considered as statistically significant. Median, quartiles, range, outliers and extrerme values, of SpO2 and Heart Rate at 10 minutes from birth was shown by: mode of delivery; maturity, maternal analgesia and maternal anaesthesia. Mann Whitney *U* test was used to compare data in minutes (median [IQR] for neonate to attain SpO2 > 75% and > 90% by mode of delivery, presence of labour and by gestational age (< 37wk versus ≥ 37wk). Quality of data was obviously maintained. Regular instruction from the supervisor was taken to control the quality of Data. All the patients was examined carefully. Regular follow-up from each patient was strictly done.

Operational definition

Term infant

An infant born between the end of the 37 week and the end 42nd week of gestation.

Late preterm infant

A late preterm infant is a premature baby born between 34 and 36 weeks gestational age. This is relatively close to full term, which is 37 weeks or greater.

Oxygen saturation

Oxygen saturation measures the amount of oxygen carrying haemoglobin in the blood.

Desaturation (Hypoxemia)

Desaturation is defined an abnormally low partial pressure of oxygen in the arterial oxygen.

Pulse oximeter

A noninvasive device that measures the arterial blood oxygen saturation by means of a sensor attached to the hand.

Heart rate in newborn

A normal newborn heart rate is between 120 and 180 beats per minute. A heart rate of less than 100 beats per min generally signifies low blood oxygen levels.

Hypoxia

Hypoxia literally means "low oxygen (< 95% in term and < 84%in preterm)", but is defined as deficiency in the amount of oxygen of that reaches the tissues of the body.

Results

A total 317 neonate were selected according to selection criteria. Among the study subjects more than half were male (57.1%). Rests were female (42.9%). Heart rate and oxygen saturation in healthy neonate immediately after birth using pulse oxymeter. The mode of delivery was mostly LUCS (96.6%). Only 5.4% cases it was NVD. Average gestational age of the study subjects was 37.47 ± 1.16 (SD) with the range of 34-40. On the other hand average birth weight was 2.88 ± 0.46 (SD) with the minimum birth weight 2.0 kg and maximum weight 4.2 kg. More than three forth of the study subjects had motion artifact (77.0%) and in 48.9% cases vernix was present. Among the study subjects high ambient light present in 3.5% cases and low perfusion present in 1.3% cases (Table 1). Acrocyanosis was present in 2.5% cases. (Figure 1) showed that differences of oxygen saturation in three minutes after delivery were statistically significant.

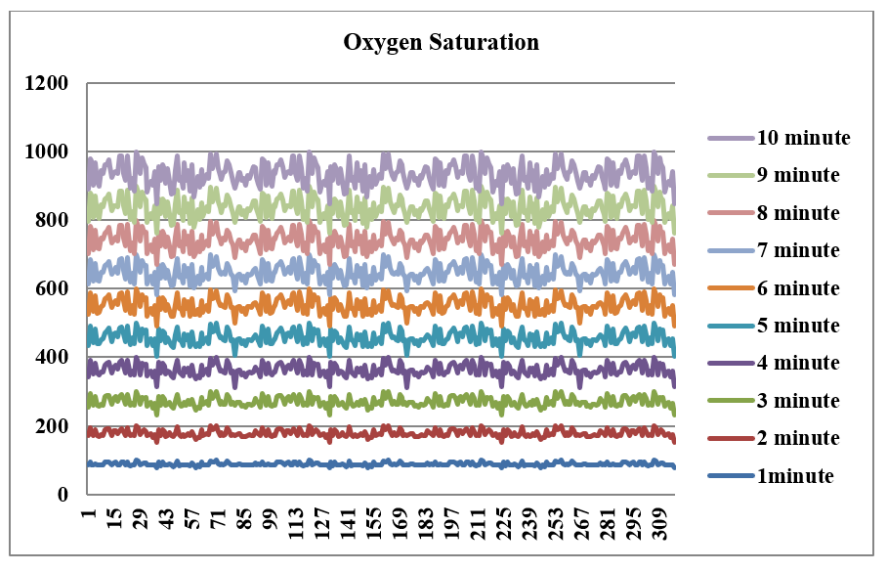

Figure 1: *Line chart of oxygen saturation in different time.*

Sex	No. of the study subjects (N)	Percent (%)
Male	181	57.1
Female	136	42.9
Total	317	100.0
Mode of delivery		
LUCS	306	96.5
NVD	11	5.4
Gestational age and Birth weight	Minimum	Maximum
Gestational age Mean±SD (37.47 ± 1.16)	34	40
Birth weight Mean±SD (2.88 ± 0.46)	2.0	4.2
Motion		
Motion artifact	244	77.0
Vernix	155	48.9
Perfusion and ambient light		
Low perfusion	4	1.3
High ambient light	11	3.5
acrocyanosis		
present	309	97.5
Absence	8	2.5

Table 1: *Sex distribution of the study subjects (N = 317).*

(Table 2) showed that differences of heart rate in two minutes after delivery were statistically significant. The median values were more in vaginal birth from 1 to 9 minutes. But median heart rate was more in 10 minutes in caesarian birth baby. But these differences were not statisticaly significant.

Minutes from birth	Heart Rate		P
	Vaginal birth	Caesarian birth	
1 minute	167 (148-168)	157 (150-160)	0.150
2 minute	163 (149-172)	154 (148-161)	0.027
3 minute	165 (150-171)	156 (148-162)	0.057
4 minute	160 (142-160)	154 (146-161)	0.898
5 minute	159 (148-165)	154 (146-161)	0.277
6 minute	155 (146-163)	154 (146-160)	0.761
7 minute	154 (143-156)	154 (144-162)	0.558
8 minute	155 (141-168)	150 (144-161)	0.504
9 minute	150 (139-163)	150 (143-158)	0.967
10 minute	148 (143-165)	150 (143-158)	0.294

Table 2: *Comparison of heart rate measured by oxymeter between infants delivered by NVD and Caesarian section (N = 317).*

(Table 3) illustrates the median (IQR) heart rate from one to ten min for preterm versus term births. At one to three minutes and at five minutes after birth preterm infants had significantly lower SpO2 measurements. From six to 10 minutes after birth and four minutes after birth there was no significant difference between SpO2 measurements for mode of delivery. Paired sample t test showed that average heart rate was more in 1 minute [155.06 ± 13.12(SD)] than in 5 minute [153.43 ± 14.13(SD)] and statistically this differences were significant (t = 2.149, p = 0.032). Pearson correlation showed high positive correlation i.e., heart rate in 5 minutes was less than heart rate in 1 minute (p = 0.000) and correlation co-efficient r = 0.509. Correlation was significant at the 0.01 level (Figure 2).

Minutes from birth	Heart Rate		P
	Preterm (< 37weeks)	Term (37 - 42 weeks)	
1 minute	147 (132 - 160)	158 (150 - 161)	0.001
2 minute	148 (140 - 155)	156 (149 - 162)	0.001
3 minute	149 (144 - 156)	157 (148 - 164)	0.001
4 minute	157 (138 - 159)	154 (146 - 161)	0.115
5 minute	149 (145 - 157)	155 (148 - 162)	0.003
6 minute	147 (145 - 159)	154 (146 - 160)	0.176
7 minute	152 (143 - 157)	155 (144 - 162)	0.128
8 minute	150 (142 - 159)	150 (144 - 161)	0.512
9 minute	146 (140 - 163)	150 (143 - 158)	0.210
10 minute	150 (142 - 159)	150 (143 - 158)	0.693

Table 3: *Comparison of heart rate between preterm and term infants (N = 317).*

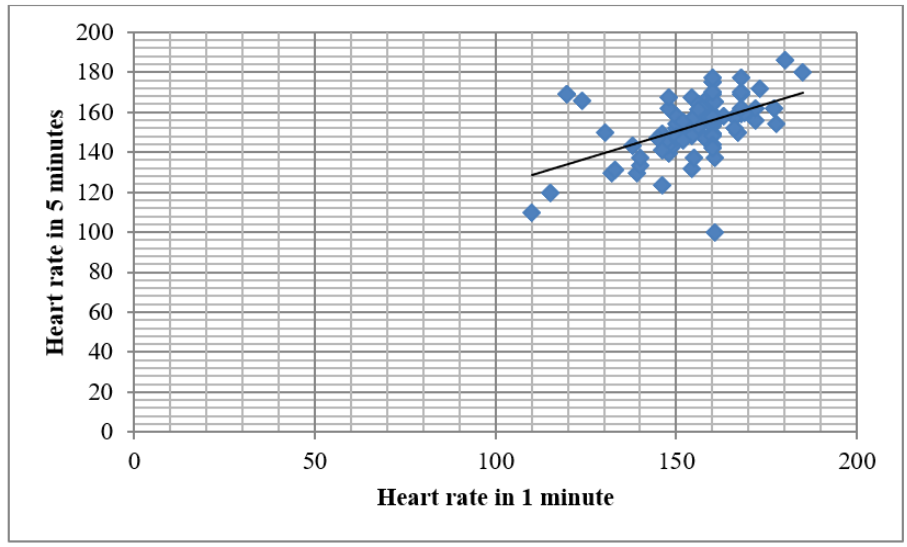

Figure 2: *Scatter diagram showed positive correlation of heart rate in 1 minute with 5 minutes.*

Paired sample t test showed that average heart rate was more in 5 minutes [153.43 ± 14.13(SD)] than in 10 minutes [150.41 ± 13.28(SD)] and statistically this differences were highly significant (t = 4.302, p = 0.000). Pearson correlation showed high positive correlation (p = 0.000) and correlation co-efficient r = 0.587. Correlation was significant at the 0.01 level (Figure 3).

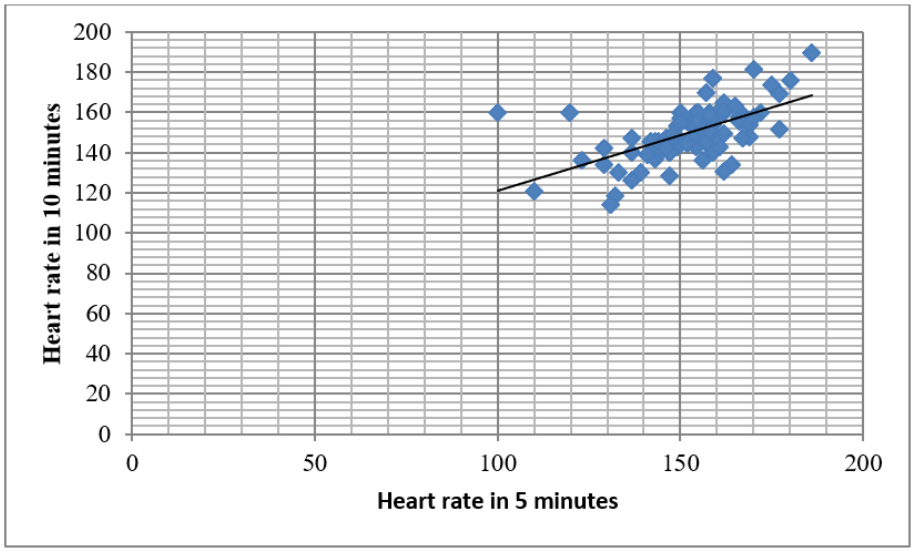

Figure 3: *Scatter diagram showed positive correlation of heart rate in 5 minutes with 10 minutes.*

Discussion

This study was carried out to construct a reference range of heart rate and oxygen saturation in healthy neonate immediately after birth using pulse oxymeter. Among the study subjects more than half were male (57.1%). Rest was female 42.9%). The mode of delivery was mostly LUCS (76.0%). Only 24.0% cases it was NVD. Average gestational age of the study subjects was 37.47 ± 1.16 (SD) with the range of 34 - 40. On the other hand average birth weight was 2.88 ± 0.46 (SD) with the minimum birth weight 2.0 kg and maximum weight 4.2 kg. Heart rate is arguably the most important objective clinical indicator of the health of newly born infants [13]. Increasing HR is considered to be a good marker of effective resuscitation, particularly when it exceeds 100 bpm [14]. Immediately after birth HR can be counted using auscultation or by palpating the umbilical cord. Both of these methods are imprecise and systematically underestimate the true HR [15]. HR can also be measured by electrocardiography (ECG). ECG is not readily available in DR, however PO is increasingly used during neonatal resuscitation [16-20]. PO accurately measures HR in newly born infants even when the HR is low.56There are several reports of SpO_2 measurements recorded in the DR with a PO [7,21-27]. These studies reporting SpO_2 measurements have been discussed previously in this chapter. However there are few reports on HR in the first minutes of life, with only a small number using PO to measure HR. In our study Paired sample t test showed that average heart rate was more in 1 minute [155.06 ± 13.12(SD)] than in 5 minute [153.43 ± 14.13(SD)] and statistically this differences were significant (t = 2.149, p = 0.032). Pearson correlation showed high positive correlation i.e., heart rate in 5 minutes was less than heart rate in 1 minute (p = 0.000) and correlation co-efficient r = 0.509. Correlation was significant at the 0.01 level. Our study the median (IQR) heart rate from one to ten min for preterm versus term births. At one to three minutes and at five minutes after birth preterm infants had significantly lower heart rate measurements. From six to 10 minutes after birth and four minutes after birth there was no significant difference between heart rate measurements for mode of delivery. In our study the differences of heart rate in two minutes after delivery were statistically significant. The median values were more in vaginal birth from 1 to 9 minutes. But median heart rate was more in 10 minutes in caesarian birth baby. But these differences were not statistically significant. In a small observational study Bustos, [28] measured the HR in 23 newly born infants. He found that at 10 minutes there was no difference between vigorous infants and those mildly depressed (Apgar score less than 7 at 1 min or 5 min). The method of recording HR in the infants studied by Bustos was not described. Brady and James, [29] measured HR by applying Welsh electrodes to the shoulders of infants as soon as they were born. In our study Paired sample t test showed that average heart rate was more in 5 minutes [153.43 ± 14.13(SD)] than in 10 minutes [150.41 ± 13.28(SD)] and statistically this differences were highly significant (t = 4.302, p = 0.000). Pearson correlation showed high positive correlation (p = 0.000) and correlation co-efficient r = 0.587. Correlation was significant at the 0.01 level. Immediately after birth, HR can be counted using auscultation or by palpating the umbilical cord. Both of these methods are imprecise and systematically underestimate the true HR.55HR can also be measured by electrocardiography (ECG). In the DR it is difficult to get ECG electrodes to stick to newly born infants who are often wet and slippery. However pulse oximetry is increasingly used during neonatal resuscitation [12-16]. The sensitivity and specificity of PO for detecting HR < 100 bpm measured by ECG were 89%and 99% respectively [30]. Infants born by vaginal delivery had a significantly higher HR than those born by caesarean from 1 to 5 min after birth ($p < 0.02$ to $p < 0.05$) [30]. Wang CL., *et al.* measured HR by PO in 15 infants < 30 weeks gestation who were actively resuscitated [29]. He reported it took a mean (range) of 2.8 (2.2 to 5.5) min to reach a HR ≥ 100 bpm, in these infants. These few published reports on the changes in heart rate of newly born infants have mostly been with older generation pulse oximeters or have included infants receiving interventions in the DR. However, they do show that HR is slowest in the first minutes after birth rising rapidly after this time.

Conclusion

Heart rate can be low in the first minutes after birth in infants with good respiratory effort and muscle tone. The main focus of this thesis was to define the reference range for measurements of oxygen saturation and heart rate in the first minutes after birth from a large cohort of infants not receiving interventions in the delivery room. My findings add to the body of knowledge regarding the change in oxygen saturation and heart rate in the first minutes after birth.

Bibliography

1. Omar F Kamlin., *et al.* "Saturation Oxgen Saturation in healthy infants immediately after birth". *The Journal of Paediatrics* 148 (2006): 585-589.

2. Henslee JA., *et al.* "Saturation Developmental patterns of heart rate and variability in prematurely-born infants with apnea of prematurity". *Early Human Development* 47.1 (1997): 35-50.

3. Yacov Rabi., *et al.* "Saturation Oxygen Saturtion trends immediately after birth". *The Journal of Paediatrics* (2006): 590-594.

4. JA Dawson., *et al.* "Saturation Pulse Oximetry monitoring infants in the delivery room; a review". *Archives of Disease in Childhood. Fetal and Neonatal Edition* 92 (2007): F4-F7.

5. Rudolph AM., *et al.* "Saturation Studies on the circulation in the neonatal period". *Paediatrics* 27 (1961): 551-566.

6. Jagdish C Das. "Monitoring of Oxygen in Neonate.7th National Conference and Scientific Session, Bangladesh Neonatal Forum (2011).

7. Andrew Lyon. Intensive care monitoring and data handling.In:Janet M Rennie. Roberton's Text book of Neonatology. Philadelphia, USA: ELSEVIER (2005): 358-359.

8. PD Macdonald and VYHYu. "Simultaneous measurement of preductal and postductal oxygen saturation by pulse oximetry in hyaline membrane disease". *Archives of Disease in Childhood* 67 (1992): 1166-1168.

9. Akhil Maheshwari and Wakdermar A. Cario. Hemolytic Disesde of the newborn (ErythroblastosisFetalis). In:Kliegman,Stanton,ST. GemeSchorBehrman. Nelson Textbook ofPediatrics.Philadelphia,USA:ELSEVIER (2012): 615-619.

10. International Liaison Committee on Resuscitation. 2005 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science with Treatment Recommendations. Part 7: Neonatal resuscitation". *Resuscitation* 67.2-3 (2005): 293-303.

11. O'Donnell CP., *et al.* "Saturation Clinical assessment of infant colour at delivery". *Archives of Disease in Childhood. Fetal and Neonatal Edition* 92.6 (2007): F465-F467.

12. Saugstad OD., *et al.* "Saturation Resuscitation of asphyxiated newborn infants with room air or oxygen: an international controlled trial: the Resair 2 study". *Pediatrics* 102.1 (1998): e1.

13. Vento M., *et al.* "Saturation Oxidative stress in asphyxiated term infants resuscitated with 100% oxygen". *Journal of Pediatrics* 142 (2003): 240-246.

14. Bohnhorst B., *et al.* "Saturation Pulse oximeters' reliability in detecting hypoxemia and bradycardia: comparison between a conventional and two new generation oximeters". *Critical Care Medicine* 28.5 (2000): 1565-1568.

15. East CE., *et al.* "Saturation Update on intrapartum fetal pulse oximetry". *The Australian and New Zealand Journal of Obstetrics and Gynaecology* 42.2 (2002): 119-124.

16. East CE. "Fetal pulse oximetry during labor: theory, clinical use and the future". *Pediatric Health* 2.6 (2008): 787-795.

17. Biarent D., *et al.* "Saturation European Resuscitation Council Guidelines for Resuscitation". *Resuscitation* 67S1 (2005): S97-S133.

18. Australian Resuscitation Council. Section 13. ARC Manual of Guidelines". *Neonatal Guidelines* (2006).

19. Dimich I., *et al.* "Saturation Evaluation of oxygen saturation monitoring by pulse oximetry in neonates in the delivery system". *Canadian Journal of Anaesthesia* 38.8 (1991): 985-988.

20. American Heart Association. 2005 American Heart Association (AHA) Guidelines for cardiopulmonary resuscitation (CPR) and Emergency cardiovascular care (ECC) of pediatric and neonatal patients: Neonatal resuscitation guidelines". *Pediatrics* 117 (2006): 1029-1038.

21. Leone TA and Finer NN. "Neonatal resuscitation: beyond the basics". *Neo Reviews* 6.4 (2005): e177-e183.

22. Clark RL., *et al.* "Saturation Use of oxygen in the resuscitation of preterm infants: Current opinion and practice in Australia and New Zealand". *Journal of Paediatrics and Child Health* 45 (2009): 31-35.

23. The role of oximetry in the first 10 minutes of age after birth. 05; Washington DC: PAS (2005).

24. Harris AP., *et al.* "Saturation Changes in arterial oxygen saturation immediately after birth in the human neonate". *Journal of Pediatrics* 109.1 (1986): 117-119.

25. O'Donnell CPF., *et al.* "Saturation Obtaining pulse oximetry data in neonates: a randomised crossover study of sensor application.

26. O'Donnell CPF., *et al.* "Saturation Feasibility of and delay in obtaining pulse oximetry during neonatal resuscitation". *Journal of Pediatrics* 147 (2005): 698-699.

27. Saugstad OD., *et al.* "Saturation Response to resuscitation of the newborn: early prognostic variables". *Acta Paediatr* 94.7 (2005): 890-895.

28. Wang CL., *et al. "*Saturation Resuscitation of preterm neonates by using room air or 100% oxygen*". Pediatrics* 121.6 (2008): 1083-1089.

29. Thilo EH., *et al.* "Saturation by pulse oximetry: comparison of the results obtained by instruments of different brands". *The Journal of Pediatrics* 122.4 (1993): 620-626.

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