

# Time Duration of Oxygen Adaptation Immediately after Birth; Monitoring by Pulse Oximeter in Perinatal Period of the Infants at Charoenkrung Pracharak Hospital

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**Background:** Oxygen Saturation is one of the important data to determine patient status and worldwide applied in several situations. Evaluation about status of immediate perinatal period of the infant usually uses clinical assessment, Apgar scoring, which had been used for a long time without other scientific measurement. Pulse oximeter, the non-invasive measurement of oxygen saturation, may play role for oxygen saturation evaluation in newborn that immediately change from intra to extra uterine environment.

**Objective:** Monitoring the time duration that immediately born infants by normal labor or Cesarean section modes, used to archived target oxygen saturation ( $SpO_2$ ) and looking for the other factors that influence oxygen saturation adaptation.

**Material and Method:** The data of the 553 infants born in Charoenkrung Pracharak Hospital, Bangkok, Thailand between October 2012 and April 2013 were collected. The 204 healthy newborns that met all criteria were studied. All infants were recorded pulse oximeter from the second to the tenth minute after birth. They were grouped by several factors such as maternal gravidity, gestational age, mode of delivery, Apgar score, birth weight, and sex. Time interval to achieve target oxygen saturation ( $SpO_2 \geq 90\%$ ) was collected for analysis.

**Results:** The oxygen saturation of infants immediately after birth showed an increase. Median time interval was 6.5 (2-10) minutes for 90% saturation and 7 (2-10) minutes for 95% saturation, respectively. Only mode of delivery showed statistical significant time difference ( $p < 0.001$ ). A Cox proportional hazards analysis of the Kaplan-Meier curves demonstrated that infants born by cesarean delivery took significantly longer time to reach a stable  $SpO_2 \geq 90\%$  than infants born by vaginal delivery (95% CI = 1.28 to 2.74;  $p < 0.01$ ).

**Conclusion:** A newly born infant has to take 6.5 minutes (2-10) after birth to adjust their oxygen saturation to reach normal higher level of extra uterine life, median  $SpO_2$  of 90%. Furthermore, mode of delivery makes a significant difference of oxygen saturation status; the cesarean route takes significantly longer time than the vaginal route to achieve  $SpO_2 \geq 90\%$ .

**Keywords:** Oxygen saturation, Vaginal delivery, Cesarean delivery, Infants

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Several clinical setting and guideline depend on oxygen status that has been evaluated by invasive investigation technique such as arterial blood gas. Pulse oximetry is a non-invasive tool for evaluating oxygen status of patient or continuous monitoring to provide appropriate management. It is widely used in intensive care unit and general practice. Nowadays, during neonatal period, clinical evaluation with Apgar scoring in newly born has been used for quite a long time to

decide management option. Although it is inconsistent, it does no harm. Because of the non-invasive technique of the pulse oximetry, and the complexity of the Apgar infant transitional period, it has been used in previous study for newborn monitoring after birth. Harris et al<sup>(1)</sup> used pulse oximetry in the immediate postpartum period to evaluate continuous changes in the neonate's  $SpO_2$ . Pulse oximetry sensor was placed at the Achilles tendon because it is easy access and is out of the way in case the neonate required resuscitation. Earlier work<sup>(1-3)</sup>, showed that neonates remain relatively desaturated in the immediate postpartum period, but the  $SpO_2$  improved steadily toward normal value during the first 24 hours. A functionally open ductus and bilateral shunting in the early postpartum period have

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been reported by several investigators<sup>(2,4,5)</sup>. In the fetus, the placenta provides for gases and metabolite exchanges. The lungs do not provide gas exchange yet, and vessels in the pulmonary circulation are still vasoconstricted. Three cardiovascular structures unique to the fetus are important for maintaining right-sided and left-sided heart circulation, the ductus venosus, the foramen ovale, and the ductus arteriosus.

Poorly oxygenated inferior vena cava blood, derived from the lower part of the fetal body, is mixed with umbilical venous blood flow (PO<sub>2</sub> of about 26-28 mmHg). This enters the right atrium and is preferentially directed across the foramen ovale to the left atrium before it flows into the left ventricle and is ejected into the ascending aorta. Superior vena cava blood, which is considerably less oxygenated (PO<sub>2</sub> of 12-14 mmHg), enters the right atrium and preferentially passes through the tricuspid valve and right ventricle and is ejected into the pulmonary artery. Because the pulmonary arterial branch is still vasoconstricted, only about 10% of the right ventricular outflow enters the lungs, whereas the major portion of bloodstream, which has a PO<sub>2</sub> of about 18-22 mmHg, bypasses the lungs and flows through the ductus arteriosus into the descending aorta to perfuse the lower part of the fetal body, after which it returns to the placenta. At birth, mechanical expansion of the lungs and increase in PO<sub>2</sub> results in a rapid decrease in pulmonary vascular resistance. For a couple days, the high arterial PO<sub>2</sub> constricts the ductus arteriosus and increases the pulmonary blood flow. The returning flow to the left atrium increases the left atrial volume and the pressure sufficiently closes the foramen ovale function, although the foramen may remain open<sup>(6)</sup>.

These mechanisms make a huge change in oxygen status observed immediately after birth. Because of its complexity, how it is changed and what are the factors that influence this transition period are questions that using the pulse oximetry may provide some answers<sup>(7,8)</sup>. Therefore, the aim of the present study focus on time interval of newly born infant to achieve appropriate oxygen saturation ( $\geq 90\%$ ), and factors affecting it.

### Material and Method

The present study was a prospective study approved by the Ethic Committee at Medical Organization of Bangkok Metropolitan Administration. Written and informed consent was obtained from each mother prior to delivery. We collected data from 553 newborns in Charoenkrung Pracharak Hospital,

Bangkok, Thailand between October 2012 and April 2013. Three hundred forty nine newborns were excluded because they received oxygen supplementation at the time of birth or other unsuitable treatment. The randomized sampling technique excluded from both modes of delivery to follow the concept of the study design, same sample size of normal labor and cesarean section groups. Subsequent results referred to the 204 healthy newborns that were equally divided into normal labor and cesarean section groups. To avoid disturbing the delivery team, we try to collect cases during normal working hours. The unstable infants that needed supporting oxygen or any resuscitation were excluded. Inclusion criteria were gestational age  $\geq 34$  weeks or birth weight  $\geq 2,000$  grams. Age in minutes, gestational age, gravidity, sex, weight of infant, and 1 and 5 minutes Apgar score were collected. All infants were assessed at birth. The time of birth was taken as the time of cord clamping that normally is done immediately after birth. Each neonate was placed on radiant warmer. Infants underwent nasal and oropharyngeal suctioning as a routine. Physical stimulation was done for infants who had difficulty establishing regular respiration or heart rate under 100 bpm. An OxyTrue A pulse oximeter (Bluepoint Medical GmbH & Co. KG, Germany) was used to measure SpO<sub>2</sub>. The right hand was cleaned with gauze sponge and pulse oximetry probe was placed over the newborn's right hand in the first two minutes of life. The right hand was selected because of proximity of the left subclavian artery and to the ductus venosus in order to eliminate effect of right to left shunt that may be found in the early phase of life. The probe and cable were connected to the oximetry body before being applied to the newborn. The pulse oximeter alarms and audible beat-to-beat indicators were silenced, as not to influence the resuscitation team's decision making.

The pulse oximeter continuously recorded arterial oxygen saturation (SpO<sub>2</sub>) using 2-second averaging times. Maximum sensitivity was set because of its increasing of sensitivity although in low-perfusion states. Pulse oximetry measurements started at the second minute and continued until 10 minutes, which was the time that the infant expected to be stabilized after transition. The nurses or pediatricians provided postpartum care and assigned Apgar scores at 1 and 5 minutes. Treatment and care of neonates was according to hospital routine and resuscitation protocol, if required, was performed by a pediatrician or anesthetist. Finally, the pulse oximeter data was transferred to PC included other infant's profiles (birth

weight, Apgar score at 1 and 5 minutes, sex, and the pulse oximeter data), which were converted into an oxygen saturation-time curve by Oxytrue A software. Each line of data was individually reviewed. We used pre-specified criteria at each time point to identify and remove questionable data. We removed data in areas of data dropout (no saturation detected), and data collected during times of sensor malfunction or misplacement (identified by the oximeter as “sensor off”). Then, we calculated the SpO<sub>2</sub> of each minute point by average SpO<sub>2</sub> maximum and minimum in one-minute interval (30 seconds before and after).

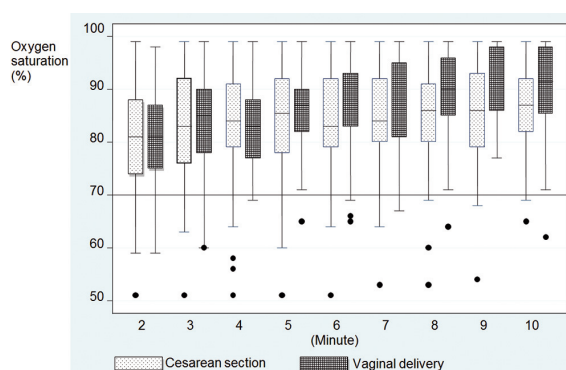
All data were statistically analyzed by STATA version 9.2. Descriptive statistics was used for demographic data and summarized as median with range for continuous variables or as number with percentage for discrete variables. The calculated power of test is at least 0.8. Category variables were reported on numbers, percentages with the times to reach a stable target SpO<sub>2</sub> of 90% based on mode of delivery that were described using the Kaplan-Meier method and compared using the Cox proportional hazards model, Hazard ratio [HR] and log rank test which calculated by factor differences with  $p < 0.05$  to consider statistically significant.

## Results

We collected data from 553 newborns between October 2012 and April 2013. Data from 349 newborns were excluded because they received oxygen supplementation at the time of birth. Subsequent results referred only to the 204 newborns that are included in the present study. A summary of patient characteristics is presented in the Table 1. Most of the newborns were  $\geq 37$  weeks gestation at birth (88.7%).

By univariate study (Table 2), we find that only mode of delivery is showing statistically significant influence on oxygen adaptation immediate after birth at target saturation  $\geq 90\%$  and  $\geq 95\%$  ( $p < 0.001$ ). Moreover, multivariate Cox regression analysis showed mode of delivery was also the independent prognostic factor as well (Hazard ratio [HR] of time to reach an SpO<sub>2</sub>  $\geq 90\%$  and SpO<sub>2</sub>  $\geq 95\%$  = 1.88 and 2.26 respectively,  $p < 0.01$ ).

Median SpO<sub>2</sub> values (IQR) at 5-minute were 87% (82% to 90%) for vaginal-delivered newborns and 85.5% (78% to 92.25%) for those delivered by cesarean section. By eight minutes of age, the median SpO<sub>2</sub> (IQR) rose to 90% (84.5% to 96%) in the vaginal delivery group and 86% (79.5 to 91%) in the cesarean delivery group (Fig. 1).



**Fig. 1** Box plots of SpO<sub>2</sub> over time among infants born by cesarean section and vaginal delivery.

In Kaplan-Meier curves plots (Fig. 2), comparison between median time period of vaginal and cesarean delivery, showed significantly different median analysis time (6 minutes in vaginal delivery vs. 8 minutes in cesarean delivery;  $p < 0.0001$ ).

## Discussion

The transitions from intra uterine life to extra uterine life involve major physiological change that finally results in higher arterial oxygen content. During this period, the neonate is in a precarious position with regard to tissue oxygen delivery. The combination of persistent right to left shunt at the arterial level, bi-directional shunting through the ductus

**Table 1.** Patient characteristics (n = 204)

Patient characteristics (n = 204)	Number (%) or median (min-max)
Gravidity	2 (1-6)
Sex of infants	
Male	114 (55.9)
Female	90 (44.1)
Weight of infant (grams)	3,080 (2,000-4,300)
Gestational age (weeks)	38.4 (34.0-42.0)
Apgars score	
1 minute	9 (1-10)
5 minutes	10 (2-10)
Delivery route	
Cesarean	102 (50.0)
Vaginal	102 (50.0)
Number of infants reaching SpO <sub>2</sub> $\geq 90\%$	204
Time to reach an SpO <sub>2</sub> $\geq 90\%$ (minute)	6.5 (2-10)
Number of infants reaching SpO <sub>2</sub> $\geq 95\%$	204
Time to reach an SpO <sub>2</sub> $\geq 95\%$ (minute)	7 (2-10)

SpO<sub>2</sub> = oxygen saturation

**Table 2.** Factors associated with oxygen adaptation immediate after birth at target saturation (90% and 95%)

	n	Time to reach an SpO <sub>2</sub> ≥90%				Time to reach an SpO <sub>2</sub> ≥95%			
		Median (95% CI)	Univariable <i>p</i> -value <sup>a</sup>	Hazard ratio (95% CI)	Multivariable <i>p</i> -value <sup>b</sup>	Median (95% CI)	Univariable <i>p</i> -value <sup>a</sup>	Hazard ratio (95% CI)	Multivariable <i>p</i> -value <sup>b</sup>
Mode of delivery									
Cesarean	102	8 (7-9)	<0.0001	1.88	0.001	8 (8-9)	<0.0001	2.26	0.001
Vaginal	102	6 (6-8)		(1.28-2.74)		7 (7-7)		(1.40-3.65)	
Gestation age									
<38 weeks	53	7 (6-8)	0.5963	0.95	0.815	8 (7-8)	0.2981	1.02	0.950
≥38 weeks	151	7 (6-8)		(0.63-1.45)		8 (7-9)		(0.61-1.69)	
Gravidity									
≤3	184	7 (6-8)	0.2461	1.32	0.307	8 (8-8)	0.1766	1.46	0.238
>3	20	7 (4-8)		(0.78-2.25)		7 (7-8)		(0.78-2.73)	
Sex of infant									
Male	114	7 (6-8)	0.9662	1.07	0.700	8 (7-8)	0.6086	1.15	0.517
Female	90	8 (6-8)		(0.76-1.51)		8 (7-9)		(0.75-1.78)	
Weight of infant									
<2,500 gms	21	8 (6-8)	0.6283	0.84	0.553	8 (6-8)	0.0679	0.54	0.062
≥2,500 gms	181	7 (6-8)		(0.48-1.48)		8 (7-8)		(0.29-1.03)	
Apgar score 1 minute									
≤9	172	7 (7-8)	0.1440	1.08	0.757	8 (8-8)	0.2778	1.07	0.831
>9	32	6 (6-8)		(0.67-1.72)		7 (7-8)		(0.60-1.91)	
Apgar score 5 minutes									
≤9	17	8 (7-10)	0.2805	1.17	0.670	8 (8-8)	0.4187	1.36	0.455
>9	186	7 (6-8)		(0.57-2.43)		8 (7-8)		(0.61-3.06)	

<sup>a</sup> *p*-value by log rank test, <sup>b</sup> *p*-value by Cox regression

**Table 3.** Previously studies of oxygen saturation target point use pulse oximetry

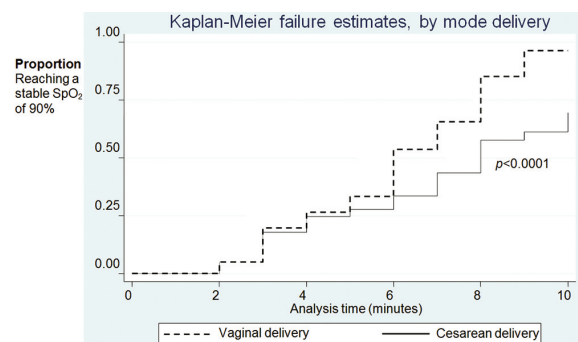
Author	Sample size	Target oxygen saturation (%)	Time (minute) median (min-max)
Harris et al. <sup>(1)</sup>	76	82	7 <sup>n</sup>
Omar et al. <sup>(10)</sup>	205	90	5.8 (1.3-20.2)
Toth B et al. <sup>(11)</sup>	50	95	12 (2-55)
The present study	204	90	6.5 (2-10)
The present study	204	95	7 (2-10)

<sup>n</sup> no range

arteriosus, and ventilation-perfusion mismatching all provide for limited oxygen reserve. Early detection of hypoxia is the most important aspect of neonatal evaluation in the delivery room.

Previous studies that sought to define the “normal” SaO<sub>2</sub> during the first few minutes of extra-uterine life included only small numbers of neonates and used intermittent blood sampling techniques with only one or, at the most, two measurements obtained during this time interval<sup>(2,4)</sup>. Pulse oximetry is a simple and non-invasive method for the continuous evaluation of SpO<sub>2</sub>. In normal situation or pulmonary disease that SpO<sub>2</sub> >80%, pulse oximetry has high accuracy in

estimating SaO<sub>2</sub> and may be used instead of arterial blood gas<sup>(12)</sup>. Its ability to responses rapidly to changes in SpO<sub>2</sub> makes it extremely useful in the evaluation of neonates in intensive care<sup>(13)</sup>. There are several studies (Table 3) that use pulse oximetry with different target oxygen saturation, 90% or 95%, that depend on objectives and researcher’s view point. In general, pulse oximetry (SpO<sub>2</sub>) is use by calculate only the ratio of oxyhemoglobin / (deoxyhemoglobin + oxyhemoglobin) which is the largest portion of oxygen



**Fig. 2** Relationship between proportion of infants reaching a SpO<sub>2</sub> ≥90% and analysis times (minutes) in difference delivery modes.



carrier; beyond deoxyhemoglobin and oxyhemoglobin, there are other hemoglobins that play small role in oxygen transport too. SaO<sub>2</sub> means all of hemoglobin that carries oxygen that represents oxygenation measured from arterial blood gas. Pulse oximeter (SpO<sub>2</sub>) is proper in evaluate or screening oxygen status in normal population who need simple sensitivity with the aim at 90%, while 95% mostly used in intensive monitoring condition. As above mention, our study collect data for both targets, 90% and 95% as well. Harris et al<sup>(1)</sup> used pulse oximetry in the immediate postpartum period to evaluate continuous changes in the neonate's SpO<sub>2</sub>.

Neonates remain relatively desaturated in the immediate postpartum period, and steadily improved toward normal value later, that due to functionally open ductus and bilateral shunting in the early postpartum period reported by several investigators<sup>(2,4,5)</sup>. Linde and Wegelius<sup>(5)</sup> demonstrated by an angiocardigraphic study in neonates the presence of bilateral shunting through the ductus arteriosus. Oliver et al<sup>(2)</sup> showed that in the immediate postpartum period, left atrial samples had a higher oxygen tension than arterial samples from the umbilical artery. Furthermore, Eldridge et al<sup>(4)</sup> found in neonates, a higher oxygen saturation in arterialized capillary finger blood than in samples obtained from the heel, indicated Right to Left shunting at the ductus arteriosus. Higher oxygen saturation obtained from right hand represents arterial oxygenation of preductal circulation, which supplies the vital organs in the upper part of the body. Therefore, during resuscitation of neonates, oxygen saturation obtained from the right hand will reflect oxygenation of the brain or heart more accurately than oxygen saturation recorded at the lower extremities. Time for infant to increase their tissue-oxygenation partly depends on the presence of residual cardiopulmonary shunts. The present study showed that during normal neonatal transition, it often takes two to eight minutes (IQR) to achieve oxygen saturation  $\geq 90\%$ , while other studies have reported 8 and 15 minutes<sup>(3,14,15)</sup>.

Our resuscitation team followed the hospital guidelines. By the way, none of the infants in the present study was identified as having any central cyanosis, despite the fact that median oxygen saturation levels at 2-minute to 4-minute were still under 85%. These may imply, the absence of visually detectable central cyanosis was not correlate to the infant's oxygen saturation underneath 85%. Although the Neonatal Resuscitation Program (NRP) recommends providing supplemental oxygen to infants who still exhibiting

cyanosis after 30 seconds of stimulation. Our results show that many newborns with low oxygen saturation may not being recognized.

Most infants included in the present study had Apgar scores of  $\geq 8$ . We excluded newborns requiring supplemental oxygen from these analyses, because our purpose was to focus on the changes in oxygen saturation at birth in healthy newborn. Apgar scoring, although excellent method of postpartum evaluation of neonates, uses skin color to access oxygenation rapidly. Our data, as well as those reported by Sendar et al<sup>(16)</sup>, demonstrated that Apgar score is potentially misleading as indicators of the degree of oxygenation. They reported that even at five minutes after birth, Apgar may be more than 8 but the median of pulse oximetry saturation values of both delivery groups were just about 85%, major discrepancies existed between Apgar scoring and SpO<sub>2</sub> values<sup>(16)</sup>. The time to achieve a steady, reliable pulse oximetry reading was appreciably longer in the present study than some previous reports. We attribute this to the strict criteria used in our study regarding the identification of a valid oximetry signal. Most of the excluded data came from the signal drop off immediately after placement of the saturation probe. The initial step was turning on the oximetry monitor, and then the oximetry cable and probe were placed on the infant's right hand respectively. We chose this method because it made minimal disturbance to the team that required a couple minutes to care for each infant prior to placing the sensor on infant's right hand. However, this method took longer time to start data acquisition (reason of the data collection usually start at the second minute after birth), compared with applying the probe and cable to the infant before turning on oximetry monitor.

There is growing interest in using oxygen saturation monitoring to make a decision on neonatal resuscitation management. However, our results suggest that early oximetry readings must be interpreted with caution. Pulse oximetry could potentially play a role in adjusting the oxygen use beyond two minutes of life, and decision to initiate oxygen supplementation should be follow pulse oximetry data of the normal saturation in each minute interval after birth. The routine application of pulse oximetry during newborn resuscitation should not be adopted until a sufficient data is available to support its use.

In the present study, comparison of mode of delivery, demonstrated that infants born by cesarean delivery had modestly lower oxygen saturations and required longer time period to reach stable oxygen

saturation  $\geq 90\%$  in the immediate newborn period compared with infants born vaginally. Whereas other factors such as maternal age, gravidity, gestational age, birth weight, Apgar score at 1 and 5 minutes and infant's gender did not show significantly difference. Furthermore, changing the target oxygen saturation to  $\geq 95\%$  also show the same result (Table 2). These may result from delayed clearance of lung fluid during operative delivery without an adequate period of labor<sup>(17)</sup>. Several reports showed that excessive administration of oxygen might lead to oxygenated injury<sup>(18,19)</sup>. Mimicking the normal rate of increase in SpO<sub>2</sub> observed in healthy newborns without routine oxygen supply will be a resuscitation strategy that may potentially limit the injury from oxygen overuse. It is anticipated that resuscitation with 100% oxygen would lead to oxygen saturation levels exceeding those found in the present study. Our limitation was narrow gestation age that mostly  $\geq 37$  weeks because preterm likely received resuscitation or oxygen support at birth, usually exclude from the study. Moreover, focusing on normal delivery, the time interval of first and second delivery stage may play role in postnatal oxygen adaptation is interesting research question for further investigation.

We have described the oxygen saturation of term and late preterm infants immediately after birth. Current clinical guidelines do not specially recommend the routine use of pulse oximetry in the delivery room setting. Our results support the feasibility of continuously measuring SpO<sub>2</sub> in the delivery room. This practice has the potential to safely guide titration of oxygen supplementation soon after birth to those newborns most susceptible to oxygenated injury.

### Conclusion

Newborn infant has to take several minutes (2 minutes to 10 minutes, min-max) after birth to adapt their oxygen saturation to achieve normal higher level of extrauterine life. In addition to median of SpO<sub>2</sub>  $\geq 90\%$  in cesarean and vaginal delivery groups was 8 and 6 minutes, respectively. Furthermore, mode of delivery make a significant different on adaptation of oxygen saturation status; cesarean delivery take significantly longer time (8 minutes) for infant to achieve normal oxygen level more than normal delivery (6 minutes).

### What is already known on this topic?

Several studies showed the newborn with oxygen saturation change since immediate after birth.

Unfortunately, most studies enrolled only small sample size which provided restrict data in the time interval that we could accept for normal infant and factors that may disturb this process.

### What this study adds?

We found the median time that newborns achieved the target oxygen saturation (90% or 95%) with larger sample size and showed different in time interval from previous studies. Furthermore, other factors such as maternal age, gravidity, gestational age, infant's gender or body weight did not show statistically different in time interval to achieve target oxygen saturation, only mode of delivery that played roll significantly.

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### Potential conflicts of interest

None.

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**Appendix.** OxyTrue A pulse oximeter (Bluepoint Medical GmbH & Co. KG, Germany) was used to measure SpO<sub>2</sub>, apply on newborn's right hand.



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## ช่วงเวลาในการปรับตัวของระดับออกซิเจนในทารกที่คลอดปกติและผ่าคลอดในระยะแรกเกิดในโรงพยาบาลเจริญกรุงประชารักษ์

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**ภูมิหลัง:** ค่าระดับความเข้มข้นออกซิเจนจัดว่าเป็นข้อมูลสำคัญในการประเมินอาการทางคลินิกและยังมีการนำไปประยุกต์ใช้ในภาวะอื่นๆ อย่างแพร่หลาย การประเมินสภาพทารกหลังคลอดนิยมใช้การให้คะแนน Apgar ซึ่งใช้อาการแสดงทางคลินิกโดยไม่ได้มีการวัดโดยใช้เครื่องมือใดๆ ร่วมด้วย ดังนั้นการวัดโดยใช้ pulse oximeter ซึ่งเป็นการวัดระดับความอิ่มตัวของออกซิเจนที่อาจถูกนำไปใช้ในการประเมินการเปลี่ยนแปลงในทารกจากภาวะในครรภ์และหลังเกิดได้

**วัตถุประสงค์:** เพื่อทำการวัดระดับความอิ่มตัวของออกซิเจนในทารกแรกเกิดด้วย pulse oximeter เพื่อดูเวลาที่ทารกใช้ในการปรับตัวไปสู่ระดับออกซิเจนเป้าหมาย ( $SpO_2$ ) พร้อมทั้งหาปัจจัยที่มีผลต่อการปรับตัวของระดับความอิ่มตัวของออกซิเจน

**วัสดุและวิธีการ:** เก็บรวบรวมข้อมูลจากทารกที่คลอดในโรงพยาบาลเจริญกรุงประชารักษ์ ระหว่างเดือนตุลาคม พ.ศ. 2555 ถึง เมษายน พ.ศ. 2556 จำนวน 553 ราย หลังการคัดออกคงเหลือทารกที่เข้าเกณฑ์ทำการศึกษาจำนวน 204 ราย โดยทำการบันทึกติดตามค่าความอิ่มตัวของออกซิเจนผ่านทางผิวหนังด้วยเครื่องตรวจ pulse oximeter ตั้งแต่หลังคลอดจนถึงนาทีที่สิบ โดยได้แบ่งกลุ่มข้อมูลออกเป็นกลุ่มแยกตามปัจจัยต่างๆ เช่น ลำดับการตั้งครรภ์ อายุครรภ์ คะแนน Apgar น้ำหนักทารกแรกคลอด และเพศทารก โดยหาเวลาที่ใช้ในการปรับเพิ่มขึ้นของค่าความอิ่มตัวของออกซิเจนจนถึงระดับเป้าหมายที่ 90% เป็นเกณฑ์ในการศึกษา

**ผลการศึกษา:** ค่าความอิ่มตัวของออกซิเจนมีการปรับตัวเพิ่มสูงขึ้นหลังคลอดโดยมีค่ามัธยฐานของเวลาที่ใช้งานถึงค่าออกซิเจนเป้าหมายที่ 90% เป็น 6.5 (2-10) นาที และค่าออกซิเจน เป้าหมายที่ 95% เป็น 7 (2-10) นาที ตามลำดับ พบว่ามีเพียงวิธีการคลอดเท่านั้นที่มีความแตกต่างอย่างมีนัยสำคัญทางสถิติของเวลาที่ใช้ไปถึงค่าออกซิเจนเป้าหมาย ( $p < 0.001$ ) นอกจากนี้ Cox proportional hazards analysis of the Kaplan-Meier curves แสดงให้เห็นว่าการผ่าตัดคลอดนั้นเป็นปัจจัยที่ทำให้ทารกใช้เวลานานขึ้นในการปรับเพิ่มระดับความอิ่มตัวของออกซิเจนเมื่อเทียบกับการคลอดธรรมชาติ ณ ค่าออกซิเจนเป้าหมายที่  $\geq 90%$  (95% CI = 1.28 to 2.74;  $p < 0.001$ )

**สรุป:** ทารกแรกคลอดต้องการเวลาในการปรับเพิ่มระดับความอิ่มตัวของออกซิเจนสูงขึ้นหลังคลอด 6.5 (2-10) นาที (median, min-max) ณ ระดับออกซิเจนเป้าหมาย 90% นอกจากนี้วิธีการคลอดมีผลต่อเวลาที่ใช้ในการปรับเพิ่มขึ้นของระดับความอิ่มตัวของออกซิเจนจนไปถึงค่าเป้าหมายแตกต่างอย่างมีนัยสำคัญทางสถิติ โดยทารกที่เกิดโดยการผ่าคลอดจะใช้เวลาในการปรับระดับค่าออกซิเจน (8 นาที) นานมากกว่าที่คลอดธรรมชาติ (6 นาที) อย่างมีนัยสำคัญ

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