# Correlation of Pulse Oximetry and Apgar Scoring in the Normal Newborns

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## ABSTRACT

**Context:** Apgar score (AS) is routinely used for assessment of newborns immediately after birth. Within acceptable limits, low saturations at birth are normal in vigorous newborn babies. Various studies have questioned the reliability of AS. **Aims:** To detect whether AS is an accurate indicator of hypoxemia and to study the correlation of different components of AS with the arterial oxygenation saturation ($SpO_2$) levels of normal newborns in the delivery room. **Settings and Design:** A prospective cross-sectional observational study on normal healthy neonates delivered vaginally in a tertiary level referral medical college. **Materials and Methods:** $SpO_2$ levels were monitored continuously in the newborns with a pulse oximeter and serial recording of $SpO_2$ levels was done at 5 min intervals starting at 1 min of life until 30 min after birth. Simultaneously, AS was recorded in these newborns at 1 and 5 min of life. **Statistical Analysis:** Data was analyzed using the Mann-Whitney–U test. **Results:** AS at 1 and 5 min of life didn't correlate with the changes in $SpO_2$ of newborns. In AS; though respiratory efforts and muscle tone were significantly correlated with $SpO_2$ of the newborns, body color did not have significant correlation with simultaneously recorded $SpO_2$. **Conclusions:** A revised AS in which evaluation of color is replaced by pulse oximetry monitoring would prove to be a better tool for neonatal evaluation in the immediate postnatal period.

**Key words:**
Apgar score, neonatal monitoring, oxygen saturation level, pulse oximetry

## INTRODUCTION

Apgar score (AS) is routinely used for assessment of newborns immediately after birth and consists of five variables viz. Respiratory efforts, heart rate, color, muscle tone, and reflex irritability. It is being used as a standardized tool for expressing the physiologic condition of newborn at birth and also to record fetal to neonatal transition. However, AS has major limitations like having a limited time frame and including subjective components. Furthermore, among the conventional variables; body color, which indicates oxygen saturation levels[1] at birth, has been reported to be a poor proxy for the arterial oxygen saturation levels.[2-5] This suggests that clinical detection of hypoxia is difficult in the newborns at birth and AS would not be influenced by it. Thus, AS would fail to report the actual status of newborn at birth.

Pulse oximetry is a non-invasive tool which can be easily used in the delivery room for continuous monitoring of the arterial oxygen saturation levels of the newborns with a high-level of accuracy.[6] It can overcome the monitoring problems during the early phase of life. It gives continuous monitoring of $SpO_2$ levels and removes the examiner bias. Hence pulse oximetry would be more accurate in reporting the exact physiological status of newborn at birth and also recording fetal to neonatal transition.

### Aims

- To detect whether AS is an accurate indicator of hypoxemia in normal vigorous babies in the delivery room
- To study the correlation of different components of AS with the arterial oxygen saturation levels of the babies in the delivery room.

## MATERIALS AND METHODS

This prospective cross-sectional observational study was conducted in the Departments of Pediatrics and Obstetrics/Gynecology of a tertiary level medical college from May 2012 to July 2012. Our study was approved by institutional ethical committee. Subjects were newborns of mothers who underwent normal vaginal deliveries in the hospital.

Inclusion criteria were: Newborns who were delivered vaginally at gestational age between 37 and 42 weeks,

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with appropriate weight for gestational age, irrespective of gender difference and had an AS of ≥7 at 1 min of life. Exclusion criteria were: Intrauterine growth retarded infants; twin deliveries; infants who required resuscitation or oxygen supplementation or suffered with any problem that required admission to Neonatal intensive care unit or had congenital anomalies. Infants whose mothers had complicated pregnancy (acute or chronic infection, fever, severe anemia, bleeding, oligohydramnios, rupture of membranes up to 12 h, meconium stained amniotic fluid, eclampsia, preeclampsia, obstructed labor, placental diseases) were also excluded from the study.

### Study protocol

Immediately after birth, the newborns were wiped with pre-warmed cloth. Their cry and vitals were observed. Cord was clamped and infants were given routine care as per neonatal resuscitation program protocol. Pulse oximeter was applied to the right wrist from the ulnar end for continuous monitoring of $SpO_2$ levels. Serial recording of preductal arterial oxygen saturation was carried out starting at 1 min of life, then at 5 min and thereafter at an interval of 5 min till 30 min of life. The pulse oximeter used was Nellcorr oximax N-600x. Simultaneously, AS was done at 1 and 5 min of life in every newborn. At the end of the observation period, newborns were weighed, assessed for gestation and breastfeeding was initiated.

### Statistical analysis

Demographic characteristics of the newborns were expressed as values of mean and standard deviation (SD) and AS values were expressed as median and interquartile range (IQR). Data was analyzed using the Mann-Whitney–U test. A $P<0.05$ was recognized as statistically significant. Sample size was limited due to the short-time duration of 3 months in this study.

## RESULTS

A total of 51, full term normal vaginally delivered newborns were included in the study. Nineteen (37%) were females and 32 (63%) were males. Mean birth weight of the infants included in the study was 2850 g with SD of 223 g. These infants had a mean gestational age of 38 weeks with SD of 0.87.

The median AS at 1 min was 7 (IQR 7-8) and at 5 min 9 (IQR 9-10) and AS at 1 and 5 min did not correlate with the level of hypoxemia at 1 and 5 min [Table 1].

After serial monitoring for 30 min, no statistically significant difference was found in the oxygen saturation levels of infants having AS of 7 compared to infants having AS of 8 at 1 min of age [Figure 1]. No significant statistical difference was found in the time taken to achieve $SpO_2$ level of ≥90% in babies with AS of 7 at 1 min and AS of 8 at 1 min [Table 2].

As per Figure 2; mean $SpO_2$ values of infants with weak and good cry at 1 min was 62% and 64% respectively ($P$=0.004). Similarly the mean $SpO_2$ values of infants with weak and

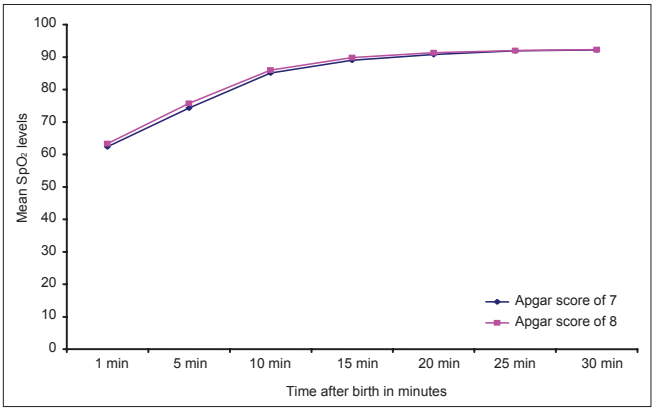


**Figure 1:** Comparison of serial $SpO_2$ between babies having initial Apgar score of 7 with babies having AS of 8 at 1 min of age

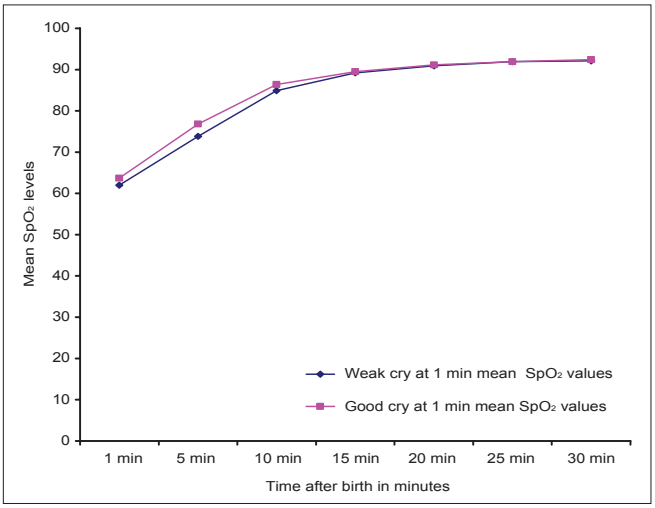


**Figure 2:** Comparison of serial $SpO_2$ between babies having weak respiratory efforts with babies having good respiratory efforts at 1 min of age

**Table 1: Apgar score and mean $SpO_2$ values of the babies in the first 30 minutes of life**

| | Time after birth (in min) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 min | 5 min | 10 min | 15 min | 20 min | 25 min | 30 min |
| Apgar score median (IQR) | 7 (7-8) | 9 (9-10) | – | – | – | – | – |
| $SpO_2$ values mean±SD % | 62.75±2.189 | 74.82±4.184 | 85.43±4.229 | 89.31±1.954 | 91±1.217 | 91.92±1.324 | 92.23±1.193 |

Apgar IQR – Interquartile range

good cry at 5 min was 74% and 77% respectively ($P$=0.002). This difference was no more statistically significant after the first 5 min of life as all the infants having weak respiratory efforts at 1 min developed strong respiratory efforts by the end of 5 min without any assistance.

Table 3 shows the relation of $SpO_2$ with muscle tone of the newborns. A statistically significant difference ($P$<0.05) was seen in the $SpO_2$ of infants with persistence of slight flexion at 5 min as compared to infants who gained full flexion at 5 min at both 5 min and 10 min of age. Similarly when $SpO_2$ of babies having both slight flexion and weak respiratory efforts at 1 min was compared with the $SpO_2$ of babies with full flexion and good respiratory efforts at 1 min, again a statistically significant difference ($P$<0.05) was found at 1 and 5 min of life [Figure 3]. This difference disappeared as soon as the infants demonstrated an improvement in their respiratory efforts and muscle tone.

Among the infants with good respiratory efforts at 1 min, no statistically significant difference was found between those with full flexion and those with slight flexion. Similarly, among the infants with weak respiratory efforts at 1 min, no statistically significant difference was found between those with full flexion and slight flexion. This suggests that muscle tone is not significantly correlated with the oxygen saturation status of newborns.

Color in AS was not an accurate indicator of $SpO_2$ in babies. Despite the mean $SpO_2$ values of 63% at 1 min, only four babies were perceived to be having peripheral cyanosis at 1 min on clinical evaluation.

The median heart rate was 138/min with IQR of 134-147. No statistically significant difference was found between oxygen saturation levels and heart rate or reflex response to catheter in nose.

**Table 2: Correlation between Apgar score at 1 minute and time to achieve $SpO_2$ ≥90%**

| Apgar score at 1 min | Time to achieve $SpO_2$ >90% (in min) | *P* value |
|---|---|---|
| 7 | 15.3 | >0.05 |
| 8 | 13.9 | |

**Table 3: Relationship between $SpO_2$ and muscle tone of babies**

| $SpO_2$ reading @ | Slight flexion at 1 min who remained slightly flexed at 5 min ($n$=28) % | Slight flexion at 1 min but full flexion at 5 min ($n$=6) % | *P* value |
|---|---|---|---|
| 1 min | 62.53 | 63.67 | >0.05 |
| 5 min | 74.18 | 77.67 | 0.008 |
| 10 min | 84.82 | 88.0 | 0.04 |
| 15 min | 89.03 | 90.17 | >0.05 |
| 20 min | 90.71 | 91.33 | >0.05 |
| 25 min | 91.71 | 92.0 | >0.05 |
| 30 min | 92.11 | 92.5 | >0.05 |

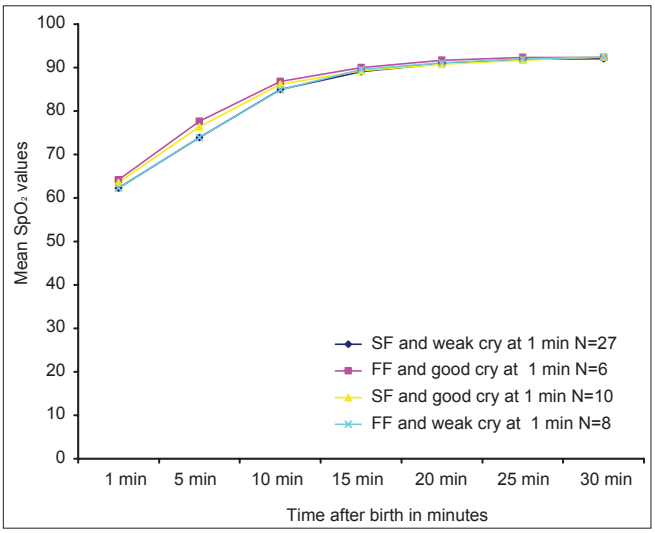


**Figure 3:** Comparison of serial $SpO_2$ levels with respiratory effort and muscle tone of babies

## DISCUSSION

Conventional AS is a numerical score which consists of 5 variables: Heart rate, respiratory effort, color, muscle tone and reflex irritability. Each of these is given a score of 0.1 and 2. The score is traditionally reported at 1 and 5 min after birth.[1] A score of 0-3 at 5 min is a suggestive criterion for asphyxial insult and is a predictor of neonatal mortality. Infants with a score of ≥7 are considered normal.[1]

Traditionally, AS is used to be a robust indicator of newborn condition at birth. It is also used as a mechanism to record fetal to neonatal transition.[7]

The evaluation of neonatal condition immediately after birth is necessary as in this period the newborn is in a precarious position with respect to tissue oxygen delivery because of persistent right to left shunt at the arterial level, bi-directional shunting through the ductus arteriosus and ventilation perfusion mismatching.[8-11] This oxygenation status is the most important aspect of neonatal evaluation and the most important factor which determines a smooth fetal to neonatal transition. AS uses the body color for demonstrating this oxygenation status.[12] Studies have demonstrated that color is a poor proxy for tissue oxygenation and hence AS is potentially misleading predictor of the degree of oxygenation.[2,11,13]

Further, studies by Richmond *et al*. have shown that babies, who had normal AS at the time of birth and did not require any postnatal assistance in the immediate postnatal period

were later found to be ill by as early as the 2nd h of birth.[14] The causes for this varied from congenital heart defects to transient tachypnea of newborn, persistent pulmonary hypertension of newborn, spontaneous pneumothorax, central nervous system (CNS) insults or congenital malformations. An important probability in such conditions could be the presence of hypoxemia which was clinically undetectable and so did not influence the AS at 1 and 5 min of life. It is possible that oxygen saturation monitoring by pulse oximetry might have detected this detrimental trend earlier. Various studies have reported the feasibility of pulse oximetry in detecting mild degrees of hypoxemia which was otherwise undetectable clinically.[15,16]

With the advent of new technologies, more studies on the use of pulse oximetry in the delivery room are forthcoming. Although, estimation of partial pressure of oxygen in the arterial blood ($PaO_2$) through arterial blood gas analysis is the gold standard to identify oxygenation status, it requires arterial puncture every time.[17] Since a constant relationship exists between $PaO_2$ and oxygen saturation of hemoglobin, pulse oximetry can be easily used to measure oxygen saturation continuously, non-invasively and without the need for calibration.[2] Studies have shown that pulse oximetry is successful in recording $SpO_2$ by as early as 1 min of life.[3,18] It has also been useful in demonstrating the pattern of changes occurring in the oxygenation status continuously over a period of time.[19]

With the help of pulse oximetry, various studies have demonstrated oxygen saturation levels as low as 60-70% in the first minute of life in normal newborns.[20-22] Study by Dimich *et al*. showed that infants with AS between 6 and 10 at 1 and 5 min had preductal $SpO_2$ values of 71.9% ± 6.5 and 83.3% ± 4.2 respectively.[11] Sendak Harris *et al*. reported a low value for $SpO_2$ at 1 min of 61 ± 5%, followed by an increase to 82 ± 2% at 7 min in infants with normal AS at 1 and 5 min.[13] In the study by Deckardt *et al*., the initial $SpO_2$ values ranged from 40 to 75% in babies with AS ≥8.[23] This ascertains that major discrepancies exist between the $SpO_2$ values and AS at 1 min and at 5 min of life. In the present study also, the mean $SpO_2$ at 1 and 5 min was found to be in the lower range whereas the median AS at 1 and 5 min was found to be normal. This suggests that AS is a potentially misleading predictor for degree of oxygenation. Further it is very subjective, having intra- and inter-observer variations in the same baby at the same time.

Since AS as a composite numerical value did not correlate with the oxygenation status of newborns at 1 and 5 min, we attempted to correlate the $SpO_2$ values with the individual variables of AS. Our study reports strong association of $SpO_2$ levels with respiratory efforts at 1 and 5 min of life. As per Figure 2, infants with weak cry at 1 min had significantly less $SpO_2$ values at 1 and 5 min as compared to infants with good respiratory efforts at 1 min of life ($P$<0.05).

Similarly $SpO_2$ levels of infants, who had slight flexion at 1 min but developed active motion at the end of 5 min, improved significantly at 5 and 10 min as compared to those who remained in the state of slight flexion at 5 min ($P$<0.05).

In the present study, despite the mean $SpO_2$ values of 62.75% at 1 min, only 4 infants were perceived to be having peripheral cyanosis at 1 min on clinical evaluation. In the past, Dimich *et al*.[11] also reported low $SpO_2$ levels of 65% in those infants who were assigned excellent AS for skin color.

The five variables used in conventional AS are interdependent.[1] Respiration affects oxygenation which affects heart rate, muscle tone and reflexes. Proper establishment of respiratory effort is the most important determinant for successful fetal to neonatal transition and has been rightly considered to be the most important variable of AS.[24] Since respiration affects oxygenation status, proper reporting of oxygenation status forms the next important aspect of neonatal evaluation and pulse oximetry can accurately demonstrate the oxygenation status in newborn. Therefore clinical evaluation of color should be replaced by pulse oximetry readings in AS. The ability of pulse oximetry to demonstrate the gradual changes in the oxygenation status of the newborn continuously and over a period of time will strengthen the ability of AS to demonstrate the fetal to neonatal transition accurately.

Our study shows that improvement of muscle tone over the first few minutes of life correlates significantly with improvement in oxygenation status.

Since all the subjects in the present study were normal newborns with normal heart rate, the association between oxygenation status and heart rate could not be demonstrated. No association was found between $SpO_2$ and reflex irritability of newborns in the present study. In the revised neonatal resuscitation program guidelines, suctioning in the nostrils, which triggers the reflex reaction, is not routinely recommended even in depressed babies.[25,26]

## CONCLUSION

AS is not an accurate indicator of oxygen saturation levels in healthy neonates whereas a revised AS in which evaluation of color is replaced by pulse oximetry monitoring may prove to be a better tool for neonatal evaluation in the immediate postnatal period.

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