Research article

Invasive versus noninvasive hemoglobin measurement by pulse CO-Oximeter in neonates admitted to NICU

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Abstract

Background
Total haemoglobin measurement (tHb) is one of the most commonly performed laboratory tests in patients admitted to the neonatal intensive care unit (NICU). Non invasive haemoglobin measurement is possible. In neonates this method can reduce iatrogenic blood loss. Studies performed in adults to compare haemoglobin (Hb) obtained with the use of non-invasive Hb monitor and laboratory method has shown a clinically acceptable accuracy of non-invasive Hb measurements. Masimo Rainbow SET, Pulse CO-oximetry developed by Masimo Corporation leverages 7 wavelengths and advanced signal processing technique to measure total haemoglobin (SpHb) values. The haemoglobin values measured through monitor is displayed continuously. This improves quality of care in babies by non invasive way. The monitor measures both pulse oximetry and SpHb with single probe which makes it advantageous.

Objective.
To compare transcutaneously spectroscopically measured hemoglobin values with venous hemoglobin values in neonates admitted to NICU.

Study Design
Prospective study in healthy preterm and term infants who were hemodynamically stable.

Results
Recordings were obtained from 76 stable infants (median gestational age at measurement: 36 weeks [range: 34–43 weeks]; median body weight: 1890 g [range: 1095–4360 g]). The spectroscopic haemoglobin values were corrected for inhomogeneous distribution of haemoglobin in the tissue. The venous and spectroscopic haemoglobin values were then compared by using the Bland-Altman method, which gave an error of <5%.

Conclusions
This is a good relation between the 2 methods for measuring haemoglobin. Larger studies are required to validate this non invasive method in those with conditions that affects the perfusion.

Key Words
Non invasive haemoglobin, Pulse co-oximetry, Invasive haemoglobin.

Introduction
Anaemia of prematurity is a common problem in the care of preterm infants that requires frequent red cell transfusions for treatment. Iatrogenic blood losses caused by venipuncture are a major cause of anaemia in premature infants. Haematopoiesis cannot produce enough new erythrocytes to balance the loss. Serum bilirubin is also done frequently in newborn which can lead to blood loss. Bilirubin measurement through bilirubinometer (transcutaneous bilirubin measurement) is in practice since many years.

Our department received Masimo radical 7 pulse CO-Oximeter a non-invasive spectroscopic technique that measures hemoglobin quantitatively and transcutaneously in preterm and term infants. Along with this based on SET (Signal extraction technology) instrument also measures saturated haemoglobin pleth variability index, perfusion index and carboxyhemoglobin and meth haemoglobin. In this study, the spectroscopically measured haemoglobin values are compared with the results of venous sampling in the same infants.

Methods
Pulse co-oximeter
Conventional pulse oximetry assumes that arterial blood is the only blood moving (pulsating) in the measurement site. Due to movement of finger, blood also moves in veins. The pulse oximeter which is routinely used cannot differentiate between arterial blood and venous blood. Pulse co-oximeter differentiates between arterial signal and venous signal based on light emission. It has filters which can cancel noise and only sends signal from arterial blood. The final result is oxygen saturation from arterial signal only and pulse rate. The technology used in measurement for non-invasive haemoglobin is based on light absorption characteristics of different haemoglobin species. By mathematical calculations it then measures total haemoglobin. Our department has pulse CO-Oximeter in NICU since last 18 months. The study was conducted from January 2013 to April 2013. The present study was aimed at quantitative measurement of the skin haemoglobin in preterm and term infants and a comparison with venous values. The venous haemoglobin was taken according to unit protocol. Whenever blood sampling was decided for complete blood count the baby was subjected to total Hb measurement and probe was applied on finger and readings were taken. After that blood sampling was done. Only those babies were selected in which complete blood
Seventy six babies were enrolled into this study. Total preterm in study were sixty two and term infants fourteen. Total male infants were 49 and female were 27. The median birth weight of the infants was 1890 g (range: 1095–4360 g), and the median gestational age was 33 weeks (range: 28–41 weeks). Perfusion index mean was 4.9(±3.1). All infants were studied only once. Saturations were 96(±1.3). (Table 1)

Measurement range of venous haemoglobin was 10.1 -16.8 with mean of 13.7 while measurement range in SpHb was 9.1 to 17.3 with mean Hb 13.2. (Table 2)

The comparison according to Bland and Altman of venous haemoglobin and the spectroscopically obtained haemoglobin showed an error of <5%, which is well within the standard range for comparing two laboratory tests. Comparison of venous haemoglobin (Hb) and spectroscopic haemoglobin values obtained showed the positive correlation coefficient is 0.98. (fig1).

Discussion
Non invasive measurement of blood contents such as total haemoglobin carboxyhaemoglobin oxygen saturations and methaemoglobin is important landmark in medical field. Pulse co-oximetry can be used for continuous haemoglobin (SpHb) monitoring. The method of measurement of total haemoglobin by pulse co-oximeter is based on light absorption and wavelengths of each signal. Conventional pulse oximeter uses two wavelengths of lights. Pulse co-oximeter uses multiple wavelengths. Recent studies compared the values obtained by venous sampling and with pulse co-oximeter. The intent of this study was to expand on those findings by testing the accuracy of SpHb in NICU patients. Haemoglobin measurement is indicated in NICU patients for various indications such as to know

### Results

#### Table 1: Gestational age and associated characteristics of patients.

<table>
<thead>
<tr>
<th></th>
<th>N=76</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preterm</td>
<td>62</td>
</tr>
<tr>
<td>Term</td>
<td>14</td>
</tr>
<tr>
<td>Male</td>
<td>49</td>
</tr>
<tr>
<td>Female</td>
<td>27</td>
</tr>
<tr>
<td>Gestational age</td>
<td>28–41 weeks Mean 33w</td>
</tr>
<tr>
<td>Birth weight</td>
<td>1095–4360g Mean 1890g</td>
</tr>
<tr>
<td>Perfusion index</td>
<td>4.9(±3.1)</td>
</tr>
<tr>
<td>Saturations</td>
<td>96(±1.3)</td>
</tr>
</tbody>
</table>

#### Table 2: Values of SpHb and venous Hb

<table>
<thead>
<tr>
<th>Sample</th>
<th>Total Hb by central lab</th>
<th>SpHb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Venous</td>
<td>10.1-16.8</td>
<td>9.1-17.3</td>
</tr>
<tr>
<td>Transcutaneous</td>
<td>13.7</td>
<td>13.2</td>
</tr>
</tbody>
</table>

#### Table 3: Difference between venous Hb and SpHb values.

<table>
<thead>
<tr>
<th>Total hb range</th>
<th>N</th>
<th>Bias (g/dl)</th>
<th>Standard deviation(g/dl)</th>
<th>Difference between total Hb and SpHb [in 0g/dl]</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;10</td>
<td>0</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a n/a n/a</td>
</tr>
<tr>
<td>10-11.9</td>
<td>5</td>
<td>0.2</td>
<td>1.1</td>
<td>80% 80% 100%</td>
</tr>
<tr>
<td>12-13.9</td>
<td>40</td>
<td>-0.4</td>
<td>0.9</td>
<td>69% 76% 96%</td>
</tr>
<tr>
<td>14-15.9</td>
<td>25</td>
<td>-0.6</td>
<td>1.0</td>
<td>65% 79% 90%</td>
</tr>
<tr>
<td>≥16</td>
<td>6</td>
<td>-1.7</td>
<td>1.0</td>
<td>13% 25% 75%</td>
</tr>
<tr>
<td>&lt;12</td>
<td>5</td>
<td>0.2</td>
<td>1.1</td>
<td>82% 82% 91%</td>
</tr>
<tr>
<td>≥12</td>
<td>71</td>
<td>-0.1</td>
<td>1.0</td>
<td>65% 80% 93%</td>
</tr>
<tr>
<td>Total</td>
<td>76</td>
<td>-0.5</td>
<td>1.0</td>
<td>68% 80% 93%</td>
</tr>
</tbody>
</table>
oxygen carrying capacity, polycythemia, and anaemia of prematurity, early judgement of bleeding, haemolytic disease of newborn. We compared values, SpHb and venous haemoglobin. Non invasive method is easy to handle, and will not cause any skin breach in preterm and term infants.

In our study we found that average SpHb measurements have bias of -0.2 with haemoglobin less than 12 and -0.1 when Hb is greater than 12. Our results are similar to the bias of -0.15 g/dl and precision of 0.92 g/dl reported by Macknet et al. (9) Macknet et al studied SpHb accuracy in patients of hemodilution. Frasca et al studied SpHb in adult patients of intensive care unit. He showed bias of 0.0.the precision was ±1.0 g/dl. (10) The findings of one study done for comparison of SpHb and venous Hb did not show comparable results. Miller et al (11) studied the accuracy of SpHb in 20 patients of spinal surgery. The difference between SpHb and total hb was greater than 1.5g/dl in 39% of observations.

A study by Van Woerkom et al using a diffuse optical spectroscopy instrument demonstrated a reliable correlation between tissue haemoglobin and venous haemoglobin before and after a red blood cell transfusion in preterm infants. (12) Heike Rabe et al study showed error of <5%, which is well within the standard range for comparing 2 laboratory tests and the positive correlation coefficient is 0.98. He studied comparison of SpHb with venous sampling in term and preterm infants. (13) Nicholas et al studied twenty seven newborn with weight less than 3000 gms. His study showed good correlation between SpHb and tHb (r=0.75, p=0.0001). The bias and precision for the tHb and SpHb values were 0.10±1.56g/dl. (1)

This could be the good alternate toward reducing iatrogenic blood loss by venipuncture to obtain a blood count. Other draw backs of traditional method are painful needle stick operational inefficiency, delayed Hb results, potential injury to patient. But study needs to be done in neonates with shock or patients with oxygen requirement or on artificial ventilation. Additional studies to establish whether the use of this method will potentially reduce iatrogenic blood loss are required. One more limitation to the study is that it did not address the economic aspects of using SpHb monitoring in place of or in addition to analysis of blood samples by the central laboratory. Pulse co oximeter is a costly instrument and studies are needed to compare both methods on financial perspective also.

**Conclusion**

Non invasive SpHb may be used as an alternative to invasive Hb measurements in neonates but large sample size are needed further for patients with shock, respiratory distress or on oxygen. Cost of radical 7 Masimo pulse co-oximeter is also very high for a country like us. Non invasive method is otherwise simple, easy, and fast and with advantages of no blood loss which is very important for premature and sick baby.

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None

**Acknowledgement**

None

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