Haemorheological parameters of umbilical cord blood of Nigerian newborns: correlations with maternal parameters

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Summary
Background: Published reports of haemorheological values of umbilical cord blood in Nigerian newborns are relatively scanty. The present study therefore aimed to determine the values of some basic haemorheological parameters in the umbilical cord blood of Nigerian neonates and in the venous blood of their respective mothers. The study also aimed to determine if any significant differences or correlations exist in these haemorheological parameters between maternal and umbilical cord blood.

Design: Cross sectional prospective study involving 60 subjects consisting of 30 newborn neonates and their respective mothers.

Methods: The values of haematocrit, erythrocyte sedimentation rate, haemoglobin concentration, red blood cell count, white blood cell count, whole blood relative viscosity, relative plasma viscosity, fibrinogen concentration, mean corpuscular volume, mean corpuscular haemoglobin and mean corpuscular haemoglobin concentration were determined in the umbilical cord blood of Nigeria neonates and in the respective mothers at the time of birth.

Results: Significantly higher values of haematocrit, haemoglobin concentration, red blood cell count, whole blood relative viscosity and relative plasma viscosity and significantly lower values of erythrocyte sedimentation rates were found in umbilical cord blood compared to maternal blood (p < 0.05). Significant positive correlations were found only in the values of erythrocyte sedimentation rate (ESR), haemoglobin concentration, white blood cell count, whole blood relative viscosity and relative plasma viscosity between maternal and umbilical cord blood (p < 0.05). Both mean corpuscular haemoglobin and mean corpuscular haemoglobin concentration showed a negative but non-significant correlation between maternal and umbilical cord blood (p > 0.05).

Conclusion: The present study reports values of basic haemorheological parameters in maternal and umbilical cord blood of newborn Nigerian neonates and reports significant differences and correlations in these parameters between the two groups. This we hope would provide information on umbilical cord haemorheology for Nigerian neonatologist since up to the present time similar studies have been scanty.

Keywords: Umbilical cord, Haemorheology, Neonate, Newborn, Haematology.

Résumé
Introduction: Des rapports publiés sur des valeurs hémorhéologiques du sang du cordon omblical sur les nouveaux nés nigérians sont relativement peu abondant. Donc, le but de cette étude est de décider les valeurs des quelques paramètres hémorhéologiques fondamentaux dans le sang du cordon ombical des néonates nigériens et dans le sang veineux de leur mères respectives. Cette étude est également pour but de décider s’il y a aucune différence importante ou corrélation dans ces paramètres hémorhéologiques entre cordon ombical du sang et maternel.

Plan: Une étude en perspective d’un groupe représentatif de la population impliquant 60 sujets y compris 30 néonates nouveaux nés et leur mères respectives.

Résultats: Les valeurs de quelques paramètres hérorhéologiques fondamentaux; hématócrits, taux de la sédimentation érythrocyte, concentration hémoglobine, compte du globule sanguin rouge, compte du globule sanguin blanc, tout le sang, viscosité relative de tout le sang. Viscosité relative du plasma, concentration fibrinogène, corpusculaire moyen de volume, hémoglobine corpusculaire moyenne et concentration d’érythrocite corpusculaire moyenne ont été décidés dans le sang du cordon ombical des néonates nigériens et chez leur mères respectives pendant la naissance. Vues plus élevées d’hématócrit, concentration hémoglobine, compte du globule sanguin rouge, viscosité relative de tout le sang et viscosité relative du plasma et valeurs plus inférieures du taux de la sédimentation d’érythrocyte ont été notées dans le sang du cordon ombical par rapport au sang maternel (p < 0.05). Correlations positives très élevées ont été notées dans les valeurs du taux de la sédimentation érythrocyte (TSE). Concentration hémoglobiné, compte du globules sanguins blancs, viscosité relative sanguine et viscosité relative sanguine et viscosité relative plasma entre maternel et cordon ombical sanguin (p < 0.05). Hémoglobine corpusculaire moyenne et concentration hémoglobine corpusculaire moyenne les deux ont montré un test négatif mais corrélation non significative entre maternel et cordon ombical sanguin (p > 0.05).

Conclusion: Dans cette étude, il s’agit d’un rapport des
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Introduction

Blood retrieved from the umbilical cord of the newborn has been found to be a potentially rich source of haematopoietic stem cells. This has lead to suggestions that transplant of umbilical cord blood is a viable alternative to bone marrow transplant for the treatment of a number of genetic disorders and certain types of cancers affecting the blood and immune system. These suggestions have been supported by the fact that umbilical cord blood unlike bone marrow is easier to obtain, less likely to evoke tissue rejection and transmit infectious agents and may thus benefit a broader range of recipients. These suggestions have been confirmed by recent reports.

These findings have thus focused research attention on the haematological parameters of umbilical cord blood: with several studies attempting to document these parameters for different population groups. For instance, values of various haematological parameters have been established for neonates in Argentina and in the umbilical cord blood of normal term neonates in India. In Japan, an increasing white blood cell count, red blood cell count, haemoglobin concentration, haematocrit and platelet count and a decreasing mean corpuscular volume and mean corpuscular haemoglobin have been reported in the umbilical cord blood during gestation. In Caucasians, maternal cigarette smoking has also been established to affect haematological parameters of umbilical cord blood: A significantly higher haematocrit score, lower reticulocyte and neutrophil counts have been reported in the umbilical cord blood of neonates of smoking mothers. The mode of delivery has also been reported to influence haematological values of the umbilical cord blood; white blood cell count was found to be significantly higher in spontaneously delivered neonates compared to neonates delivered by other means.

In Nigeria, though umbilical cord blood hematopoietic stem cell transplant is still far fetched, studies on the haematological parameters of umbilical cord blood are in addition relatively scanty. Several reports from Nigeria have focused mainly on haematological parameters in pregnant Nigerian subjects and in healthy newborn neonates. Reports specific to the umbilical cord have been even scantier. A recent report specific to umbilical cord blood from Jos, Nigeria was exhaustive, providing values for only haemoglobin concentration and packed cell volume. The present study therefore reports values of a number of basic haemorheological parameters in the umbilical cord blood of Nigerian neonates and in the respective maternal blood at the time of delivery: This is with the objective of determining statistically significant differences and correlations in these parameters between maternal and umbilical cord blood. This we hope would provide basic reference values and information for umbilical cord haemorheology for the Nigerian neonatologist.

Materials and methods

Subjects: A total of 60 subjects were recruited into the study. This consisted of 30 mothers and their respective newborn neonates. The mothers were aged between 19 and 40 years. All mothers were booked and received ante natal care until delivery at the ante natal clinic of a tertiary health care center in Port Harcourt, Nigeria. Each mother gave informed consent and none had antecedent history of haematologic, cardiovascular, endocrine, metabolic or neurologic disease. None of the mothers admitted to a history of cigarette smoking. All mothers had an uneventful ante natal period with normal spontaneous vertex delivery of a singleton fetus at the labor ward of the selected hospital. All the newborns were physically examined at birth and found to be normal and apparently healthy. None had any gross congenital malformation or acquired disease at birth. All newborns were of normal weight for gestational age.

Blood collection: On delivery, each mother was allowed to rest for at least 30 minutes and 5 mls of blood collected from an ante cubital vein with the mother supine and with minimum stasis. Blood was carefully collected from the umbilical cord within 10-15 minutes of the delivery of the baby. The blood samples were immediately transferred into trisodium citrate bottles and carefully mixed. The blood samples were properly identified, paired and immediately stored in the blood bank till ready for analysis. All specimens were analyzed within 2 hours of collection.

Method: Haematocrit was estimated using Hawksley micro-capillary tubes centrifuged at 3000 r.p.m. for 10 minutes. The mean of two separately obtained reading was taken as the haematocrit value. Erythrocyte sedimentation rate was estimated by the method of Westergren. Haemoglobin concentration was estimated by the cymnethaemoglobin method; red blood cell and white blood cell counts were determined manually using the improved Neubauer counting chamber as described by Dacie and Lewis (1991). Whole blood relative viscosity and relative plasma viscosity were determined by capillary viscometry using a method first described by Reid and Ugwu in 1987 and modified by Dapper and Didia (2002). Fibrinogen concentration was determined by the clot-weight method as described by Ingram (1961). The mean corpuscular volume, mean corpuscular haemoglobin and mean corpuscular haemoglobin
concentration were calculated from the value of the appropriate haematologic parameter determined [6].

All haemorheological parameters were determined in both the umbilical cord blood and the corresponding maternal blood at room temperature (27°C±0.5).

Statistics: The means, standard deviations and ranges were calculated. Attempt was made to determine any significant differences and/or correlations for each haemorheological parameter between maternal and umbilical cord blood. This was done using the Student’s t-test and the Pearson correlation coefficient respectively. A p value less than 0.05 was considered statistically significant in each circumstance. The results obtained are as presented in the Table 1.

Results
Tables 1, 2 and 3 show the mean values, standard deviations and ranges of the haemorheological parameters determined in both the maternal and umbilical cord blood in the present study. Attempt was made to group parameters performing essentially similar functions together. The tables also show significant differences and correlations between maternal and umbilical cord blood for the various haemorheological parameters under investigation. Significantly higher values of haematocrit, haemoglobin concentration, red blood cell count, whole blood relative viscosity and relative plasma viscosity and lower erythrocyte sedimentation rate were found in the umbilical cord blood compared to maternal blood (p<0.05). Results obtained indicate that erythrocyte sedimentation rate, haemoglobin concentration, white blood cell count, whole blood relative viscosity and relative plasma viscosity showed significant positive correlations between maternal and umbilical cord blood (p<0.05). Haematocrit, red blood cell count, fibrinogen concentration and mean corpuscular volume all showed positive but non significant correlation; while both mean corpuscular haemoglobin and mean corpuscular haemoglobin concentration showed an inverse (negative), but non sig

### Table 1 Values of haematological parameters in maternal and umbilical cord blood

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean ± SD (Range)</th>
<th>Significant differences (t-test)</th>
<th>Significant correlation (Pearson’s)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Umbilical cord</td>
<td>Maternal blood</td>
<td></td>
</tr>
<tr>
<td></td>
<td>blood</td>
<td></td>
<td></td>
</tr>
<tr>
<td>H(%)</td>
<td>41.8±6.57 (21-50)</td>
<td>31.8±4.53 (22-41)</td>
<td>p&lt;0.05</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>r=0.2164</td>
</tr>
<tr>
<td>HC (g/dl)</td>
<td>13.7±3.16 (10.2-16.7)</td>
<td>10.6±1.5 (7.4-13.8)</td>
<td>p&lt;0.05</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>r=0.4249</td>
</tr>
<tr>
<td>RBCC (x10^6/L)</td>
<td>4.62±0.87 (1.8-5.6)</td>
<td>3.37±0.57 (2.1-4.4)</td>
<td>p&lt;0.05</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>r=0.2153</td>
</tr>
<tr>
<td>WBCC (x10^6/L)</td>
<td>9.88±2.93 (4.7-16.8)</td>
<td>8.77±4.4 (3.3-19.1)</td>
<td>p&gt;0.05</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>r=0.5582</td>
</tr>
</tbody>
</table>

All values mean ± SD, range in parentheses.
*H* = Haematocrit; *HC* = Haemoglobin concentration; *RBCC* = Red Blood Cell Count; *WBCC* = White Blood Cell Count.

### Table 2 Values of rheological parameters in maternal and umbilical cord blood

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean ± SD (Range)</th>
<th>Significant differences (t-test)</th>
<th>Significant correlation (Pearson’s)</th>
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<tbody>
<tr>
<td></td>
<td>Umbilical cord</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>blood</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ESR (mm/1hr)</td>
<td>2.93±2.79 (1-13)</td>
<td>28.8±3.65 (1-130)</td>
<td>p&lt;0.05</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>r=0.2674</td>
</tr>
<tr>
<td>WBRV</td>
<td>3.32±0.74 2.03-4.85</td>
<td>2.85±0.66 2.03-4.04</td>
<td>p&lt;0.05</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>r=0.3514</td>
</tr>
<tr>
<td>RRV</td>
<td>1.48±0.34 1.05-2.94</td>
<td>0.79±0.16 0.57-1.41</td>
<td>p&lt;0.05</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>r=0.6253</td>
</tr>
<tr>
<td>FC (g/dl)</td>
<td>1.05±0.63 1.01-1.05</td>
<td>1.11±0.03 1.04-1.17</td>
<td>p&gt;0.05</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>r=0.1974</td>
</tr>
</tbody>
</table>

All values mean ± SD, range in parentheses.
*ESR* = Erythrocyte Sedimentation Rate; *WBRV* = Whole Blood relative viscosity; *RRV* = Relative Plasma Viscosity; *FC* = Fibrinogen concentration
significant correlation (p>0.05). Noteworthy, were: Haemoglobin concentration, whole blood relative viscosity and relative plasma viscosity that were found to be significantly higher in umbilical cord blood and to correlate significantly with maternal values; erythrocyte sedimentation rate was found not only to be significantly lower in umbilical cord blood, but also significantly correlated with maternal values; white blood cell count did not show any significant differences between maternal and umbilical cord blood but was significantly correlated between both groups.

Discussion

The present study reports for the first time values of some basic haemorheological parameters in the umbilical cord blood of healthy term neonates in Nigeria. The study also reports maternal blood values of these parameters. Manual methods were used in the present study because automation was not readily available in our centre; nonetheless this does not detract from the implications of our findings. The maternal haemorheological values reported in the present study are similar to published data on pregnant Nigerian women. The results of the present study are fairly consistent with the report from Jos, Nigeria of umbilical cord blood by Odey and Iba (2003). The significantly higher haematocrit, haemoglobin concentration, and red blood cell count seen in umbilical cord blood compared to maternal blood is expected, being fairly well established in Caucasians. The lower maternal values of these parameters could be attributed mainly to the effect of haemo-dilution due to blood volume expansion characteristic of pregnancy. Expectedly, we report lower values of haemoglobin concentration in the umbilical cord blood of Nigerian newborns compared to Caucasian or Indian neonates. We also report lower values of haemoglobin, haematocrit, mean corpuscular volume and mean corpuscular haemoglobin compared to values obtained in a recent study from Argentina. The umbilical cord blood values reported in the present study are in the same range with values from a similar study in normal black Zimbabwean neonates; results from both studies are in addition lower than published values for Caucasian neonates. Reasons for these differences are not immediately clear. The significantly higher erythrocyte sedimentation rates seen in maternal blood is possibly due to the effect of pregnancy in African women. The present study reports significantly higher values of whole blood relative viscosity and relative plasma viscosity in the umbilical cord blood of newborns compared to maternal blood. This is likely due to the effect of the higher red blood cell count and haematocrit seen in umbilical blood; since no significant differences were observed in the values of fibrinogen concentration between maternal and umbilical cord blood. Both erythrocyte population and fibrinogen concentration play important roles in determining the rate of erythrocyte sedimentation. The result of our study apparently suggests that umbilical cord blood is more viscous than maternal blood. The physiological significance of this distinction is yet unclear. Unexpectedly, we were unable to demonstrate significant differences in any of the corpuscular indices between maternal and umbilical cord blood. This is despite the fact that the significant differences were found to exist in the values of haematocrit, haemoglobin concentration and red blood cell count between maternal and umbilical cord blood. Significant correlations between maternal and umbilical cord blood for erythrocyte sedimentation rate, haemoglobin concentration, white blood cell count, whole blood relative viscosity and relative plasma viscosity were observed. Noteworthy is the value of white blood cell count which although was not significantly different between maternal and umbilical cord blood, but however showed a significant positive correlation between both groups. This suggests a direct positive association of leucocyte population between maternal and umbilical cord blood. To the best of our knowledge previous reports in this regard have been scanty, although the clinical utility of white blood cell and differential counts in the neonatal period is doubtful due to a wide physiological variation. Correlations of whole blood relative viscosity and relative plasma viscosity between maternal and umbilical cord blood also suggest a direct viscous relationship between maternal and umbilical cord blood. The significance of which is also presently unclear. Both
mean corpuscular haemoglobin and mean corpuscular haemoglobin concentration showed negative correlation between maternal and umbilical cord blood. This finding is consistent with previous reports in this regard. Unlike, previous studies however, we were unable to demonstrate negative correlations for mean corpuscular volume; a fall in mean corpuscular volume has been reported with increasing gestation. In conclusion, the present study reports values of basic haemorheological parameters in maternal and umbilical cord blood of healthy term newborns in Nigeria. Umbilical cord blood was found to have significantly higher values of haematocrit, haemoglobin concentration, red blood cell count, whole blood relative viscosity and relative plasma viscosity and lower erythrocyte sedimentation rate compared to maternal blood (p < 0.05). Significant positive correlations were found between maternal and umbilical cord blood for erythrocyte sedimentation rate, haemoglobin concentration, white blood cell count, whole blood relative viscosity and relative plasma viscosity. The present study could be of relevance in Nigeria, since up to the present time similar studies have been relatively scanty.

References