REFERENCES


Blood Viscosity in the Normal Newborn Baby

C. W. VAN DER ELST, A. F. MALAN, H. DE V. HEESE

SUMMARY

A viscometer was tested and the results were found to be accurate and reproducible for the ranges encountered in neonates. The viscosity was determined in 80 cord blood samples and the mean and 2 standard deviations (2 SD) were calculated at each shear rate. Changes in viscosity increased from birth to 12 hours, and then gradually decreased over the next 72 hours. The results are in keeping with the accepted normal values in the newborn.


Few workers have determined the viscosity of umbilical cord blood,1-3 and their results have differed. Studies on venous blood viscosity after birth6,5 have shown an even greater divergence of findings (Fig. 1). It is therefore difficult to define hyperviscosity and to determine which babies are at risk of the complications6 which may result from this condition.

The purpose of this study was to determine the accuracy and reliability of a cone and plate viscometer and to define normal absolute viscosity levels in the newborn population of our area.

MATERIALS AND METHODS

The Viscometer and its Reliability

The Model LVT Micro Viscometer (Wells-Brookfield, Stoughton, Mass., USA) consists of a conical disc which is rotated in a small rhodium cup containing the sample to be tested (Fig. 2). The drag on the rotating cone due to the viscosity of the fluid is reflected by a spring and pointer on a dial. The deflection of the pointer bears a linear relationship to the torque applied to the spring via the cone. With this reading and the use of precalculated range tables, the absolute viscosity in centipoise (cP) units is obtained. The cone can be made to rotate at different speeds (shear rates) by means of a gear transmission connected to a motor. The cup is surrounded by a water jacket connected to a constant-temperature water bath. The details of the geometry and operation of the instrument have been discussed elsewhere.6-9

Fig. 1. Comparison of blood viscosity v. shear rate in 5 different studies.
TABLE I. VISCOSITY OF 80 CORD BLOOD SAMPLES AT VARYING SHEAR RATES

<table>
<thead>
<tr>
<th>Shear rate (s⁻¹)</th>
<th>Mean</th>
<th>±2 SD</th>
<th>SEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>11.5</td>
<td>8.73</td>
<td>6.96</td>
<td>3.8</td>
</tr>
<tr>
<td>23</td>
<td>5.54</td>
<td>4.62</td>
<td>2.6</td>
</tr>
<tr>
<td>46</td>
<td>1.8</td>
<td>1.4</td>
<td>0.08</td>
</tr>
<tr>
<td>115</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>230</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
</tr>
</tbody>
</table>

SEM = standard error of mean.

To test the accuracy and reliability of the viscometer, silicone oils of known viscosities 5 and 50 cP were tested alternatively in the instrument. Each sample was tested 15 times at a shear rate of 146 s⁻¹ at 25°C. When oil with a viscosity of 5 cP was used, the viscometer gave readings within 3%, i.e. 0.15 cP of the known value. For oil of 50 cP the accuracy was 2.4%, i.e. 1.2 cP of the expected value. The paired t-test showed no significant difference (P>0.2) in 15 alternate determinations of the two oil samples.

Cord Blood

Studies were made on cord blood from 80 full-term (37 - 41 weeks) healthy newborn babies who were appropriate for gestational age. All the mothers had had an uncomplicated antenatal period followed by a normal vaginal delivery.

Venous Blood

Ten babies born by elective caesarean section were studied at delivery, at 12 hours, and on the second, third and fourth days of life. The umbilical cord was clamped early (at 5 - 15 seconds) in all cases except in 1, when clamping was delayed for 38 seconds. In all cases the reason for the caesarean section was thought not to have affected the blood viscosity of the baby. Informed consent was obtained from each mother, and blood was taken from the antecubital or external jugular vein of each infant. Laboratory investigations included placental histology, calcium, magnesium and IgM determinations.

Fresh blood samples were placed into heparinized tubes (25 U/ml) and mixed gently to prevent clotting. Viscosity analysis was made within 8 hours at 37°C at shear rates from 11.5 to 230 s⁻¹.

RESULTS

Cord Blood

In Table I the results of the 80 cord blood determinations are shown. Fig. 3 illustrates that not only the viscosity but also the range, ± 2 standard deviations (2 SD), increases with the decreasing shear rate. The standard error of the mean, although small, is also greatest at low shear rates. The mean cord haematocrit was 49.2% (± 2 SD 10.2%) and the mean weight of the babies was 3210 g (± 2 SD 980 g).

Fig. 3. Viscosity at varying shear rates in 80 cord blood samples (mean ± 2 SD).

Venous Blood in the First 4 Days of Life

In Table II the viscosity findings over a 4-day period in the 10 babies born by caesarean section are given. As can be seen from Fig. 4, the viscosity increased from birth to 12 hours and then tended to stabilize by about day 3. The range of normal (± 2 SD) decreased progressively over the 4-day period. All laboratory investigations were normal for these babies.

DISCUSSION

There are various viscometers available for the measurement of blood viscosity. The type tested here is suitable...
TABLE II. VISCOSITY AT VARYING SHEAR RATES IN 10 NORMAL BABIES (MEAN ± 2 SD)

<table>
<thead>
<tr>
<th>Sample time</th>
<th>N</th>
<th>11.5</th>
<th>23</th>
<th>46</th>
<th>115</th>
<th>230</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birth (cord)</td>
<td>10</td>
<td>7.72 ± 3.3</td>
<td>6.03 ± 2.12</td>
<td>5.03 ± 1.63</td>
<td>4.14 ± 1.24</td>
<td>3.78 ± 1.2</td>
</tr>
<tr>
<td>12 h</td>
<td>9</td>
<td>9.73 ± 4.98</td>
<td>7.82 ± 3.74</td>
<td>6.43 ± 2.74</td>
<td>5.25 ± 2.08</td>
<td>4.82 ± 2.08</td>
</tr>
<tr>
<td>24 - 48 h</td>
<td>10</td>
<td>9.41 ± 4.12</td>
<td>7.49 ± 2.66</td>
<td>6.01 ± 1.96</td>
<td>4.92 ± 1.52</td>
<td>4.36 ± 1.38</td>
</tr>
<tr>
<td>48 - 72 h</td>
<td>10</td>
<td>9.0 ± 3.32</td>
<td>7.14 ± 2.26</td>
<td>5.85 ± 1.56</td>
<td>4.70 ± 1.2</td>
<td>4.25 ± 1.06</td>
</tr>
<tr>
<td>72 - 96 h</td>
<td>9</td>
<td>9.19 ± 2.70</td>
<td>7.49 ± 1.84</td>
<td>6.13 ± 1.16</td>
<td>4.93 ± 0.88</td>
<td>4.38 ± 0.82</td>
</tr>
</tbody>
</table>

Fig. 4. Blood viscosity at varying shear rates in 10 babies at birth, at 12 hours, and at days 2, 3 and 4 (mean ± 2 SD).

for use in newborn infants, because the range of measurement allows enough latitude for blood of high viscosity. The results of this study show that the instrument is accurate and that reproducible readings are obtained when the same sample is tested repeatedly. The accuracy, however, does tend to be less at lower shear rates. The viscometer was simple to operate, and on average a sample could be analysed at 5 shear rates in 15 - 20 minutes.

The cord blood values in this series were found to be comparable with those found by Gross et al. in Denver. Since most workers use the Denver results as standard, it is satisfying to know that our results are similar. The mean cord blood hematocrit value of 49.2% is also in agreement with that of other studies.\(^{1,9,10}\) The increase in blood viscosity from delivery to 12 hours was found to parallel that of the hematocrit values. The viscosity then tended to decrease over the next 48 hours. These changes are probably due to fluid shifts to and from the intravascular space.\(^{21,32}\)

It is not clear why our results, both at birth and in the first 4 days of life, are different from those of other studies quoted, despite use of the same method. Bergqvist\(^3\)\(^{22}\) results were almost double those of this study, but factors such as error in instrumentation, temperature, pH and red blood cell deformability may be partly responsible. Our mean hematocrit results over the 4-day period did not change more than 4.5%.

The results of this study reflect normal cord blood viscosity in the Cape Town Coloured population, and show the variations to be expected in the first 4 days of life. In view of the serious nature of the possible complications of hyperviscosity, it is important to know the normal values.

This research was sponsored by the South African Medical Research Council.

REFERENCES