patient with a genetic disorder, a remarkably high number appeared to be unaware of the genetic component of diseases they had encountered in their practice.

On average, about 60% of the respondents were not familiar with the risks of recurrence associated with the dominant, recessive and X-linked modes of inheritance.

**GENERAL CONCLUSION**

This research has provided the Department of Health with valuable guidelines for the planning and execution of a genetic education programme. We have found South African women to be very interested in medical genetics and eager to make use of the new techniques, such as selected abortion of affected fetuses. In the majority of cases, the doctor was the first person approached for help with a genetic problem, and magazines were the major source of general knowledge about the subject.

The group of doctors completing the questionnaire revealed several areas in which knowledge of medical genetics was incomplete. Since the majority indicated their training as their major source of knowledge, it seems logical that the genetic content of medical undergraduate courses should be maximized. At present, only two universities in the country have a Chair in Human Genetics. Furthermore, the more recently qualified doctors gave more accurate answers than those in the older age groups, indicating the definite need for refresher courses in human genetics — in particular, its practical applications in medicine.

The same principles apply to nursing personnel, whom we believe to be key members of the genetic health team. The nurses report that they want to know more about genetics. Therefore, they are apparently not learning enough genetics during their training. Plans are now being made to increase the genetic content of nursing curricula at all levels and courses are offered to qualified nurses in the field.

It is planned to repeat this research after a number of years, in order to evaluate the success of our education programme, to detect changes in the attitudes of South African society towards medical genetics, and to acquire new guidelines for future educational activities. Research into the knowledge and attitudes of the non-White population groups will also be required, as well as research into the psychosocial problems accompanying inherited and congenital disorders.

**REFERENCES**


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**Haematocrit Values and Blood Viscosity in the Newborn Infant**

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

**SUMMARY**

The haematocrit values in 51 babies were studied to observe the possible variations due to the method and time of sampling and to relate these findings to blood viscosity. A good correlation \((r = 0.9536)\) between haematocrit values of warmed heel capillary blood and of central venous samples was found. Prediction of the venous value from a known sample of capillary blood can be made using regression lines and 95% confidence limits. The correlation between venous and unwarmed blood samples from the heel is not as good. A central venous haematocrit value of 65% or greater gave a 100% risk of the infant's blood being hyperviscous. Hyper­viscosity occurred in 71% of infants with a capillary haemato­crit value of 65-68% but the figure rose to 81% when the peripheral haematocrit value was 68% or more.


There are several causes of a high haematocrit value in the newborn baby. These include chronic intra-uterine hypoxia, twin-to-twin, maternal-fetal and placental trans-
fusions, maternal diabetes and chromosomal abnormalities.

The diagnosis of polycythaemia and therefore of hyperviscosity is usually based on a central venous haematocrit value of more than 65%. It is important to be able to detect this condition in infants by using peripheral capillary blood samples. It is therefore of great value to know the relationship between venous and capillary haematocrit values and the extent to which it may alter in the first days of life.

The aims of this study were to investigate these relationships and changes in the normal infant, and to determine a peripheral haematocrit level above which hyperviscosity is likely to occur.

**SUBJECTS AND METHOD**

A total of 51 babies was studied at Groote Schuur Maternity Hospital. Of these, 22 were male and 29 were female. Their mean weight was 2,922 g, with a range of 1,810 - 4,530 g. There were 48 Coloured and 3 Black babies.

To observe the variations of haematocrit values in the same normal term infant, 10 newborn babies were studied. They were all born by elective caesarean section for various reasons, none of which would affect their haematocrit values. The umbilical cord was clamped as rapidly as possible, the longest delay being 38 seconds after delivery. Venous umbilical cord blood was taken at birth. At 12 hours and on the second, third and fourth days of life central venous, warmed and unwarmed heel blood samples were obtained. The physical examination, placental histology, IgM levels and blood electrolytes were all normal. Informed consent was obtained in each case.

To determine the relationship between central and peripheral haematocrit values and the critical level above which hyperviscosity is likely to occur, a second group of 41 babies was studied alongside the first group. These infants had been referred because of an unwarmed heel prick haematocrit value of more than 65%. No details of time of cord clamping were known. Thirty-eight were term infants (37 - 41 weeks), 3 were premature (35, 40 weeks) and 8 were small for gestational age.

In all 51 infants 2 ml of blood was taken from the antecubital or external jugular vein. A few minutes later capillary blood was obtained by pricking an unwarmed and then a warmed heel. The foot was placed in a water bath at 40 - 42°C for 5 minutes, dried and a sample taken with a 3-mm lancet. Gentle squeezing was usually necessary in both the venous and heel prick samples, but this was done well away from the site of the puncture.

The capillary tubes were sealed, spun in a microcentrifuge at 12,000 rpm for 5 minutes and the haematocrit values read in the standard way. The error of instrumentation was found to be ±2% of the observed values when 18 paired samples were compared. Blood viscosity was measured on a Wells-Brookfield Micro Viscometer Model LVT at 37°C. Hyperviscosity was considered to be present if viscosity was above the normal levels previously established for this population.

**RESULTS**

Table I shows the mean haematocrit value at the various times of sampling in 10 normal babies. From a mean cord blood value of 46.2% the value increased to 50.7% at 12 hours and levelled out thereafter. The warmed heel prick value was on average 2% higher than that of cord blood, but paralleled the central venous value over the 4-day period. There was no such relationship between the values for central venous and unwarmed heel blood. The central venous haematocrit value over the 4-day period was 48.1% (SD ± 4.75%), for warmed blood it was 49.6% (SD ± 4.12%) and for unwarmed blood 53.1% (SD 4.96%).

On analysis with the paired t test no significant differences could be shown between central venous and warmed heel prick samples on any of the days (P = 0.45). Blood taken from the unwarmed heel, in contrast, had a much higher value than that of central venous blood (P<0.02). Although there are differences between the two methods of heel prick sampling, these are not significant (P>0.05).

From Table II it can be seen that although there is a good correlation between all three methods of sampling, the best is achieved between central venous and a warmed heel prick sample (r = 0.9542). Fig. 1 shows the regression line and 95% tolerance limits for the central venous and warmed heel values. The intercept is at 0.24 and the slope is 0.92. The individual values form a fairly tight cluster along the regression line.

**TABLE II. HAEMATOCRIT CORRELATIONS BETWEEN DIFFERENT METHODS OF SAMPLING**

<table>
<thead>
<tr>
<th>Sample site combinations</th>
<th>Correlation (r)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central venous v. warmed heel</td>
<td>0.9542</td>
</tr>
<tr>
<td>Central venous v. unwarmed heel</td>
<td>0.7932</td>
</tr>
<tr>
<td>Unwarmed v. warmed heel</td>
<td>0.7888</td>
</tr>
</tbody>
</table>

The risk of a polycythaemic infant having hyperviscous blood is shown in Table III. The blood of all babies with a central venous haematocrit value of 65% was hyperviscous. The risk was considerable (71%) when the warmed heel prick haematocrit was 65% or greater. One infant in the series had a central venous haematocrit value of 63% and was found to be hyperviscous.

**TABLE I. MEAN HAEMATOCRIT VALUES IN 10 NORMAL BABIES OVER 4-DAY PERIOD**

<table>
<thead>
<tr>
<th>Sample site</th>
<th>Birth (cord blood)</th>
<th>12 hours</th>
<th>Day 2</th>
<th>Day 3</th>
<th>Day 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central venous</td>
<td>46.2</td>
<td>50.7</td>
<td>47.1</td>
<td>47.7</td>
<td>47.5</td>
</tr>
<tr>
<td>Warmed heel</td>
<td>—</td>
<td>52.8</td>
<td>48.1</td>
<td>49.8</td>
<td>49.2</td>
</tr>
<tr>
<td>Unwarmed heel</td>
<td>—</td>
<td>55.2</td>
<td>52.0</td>
<td>55.0</td>
<td>50.7</td>
</tr>
</tbody>
</table>
TABLE III. RISK OF HYPERVISCOSITY ACCORDING TO HAEMATOCRIT VALUES OF SAMPLES OF DIFFERENT SITES

<table>
<thead>
<tr>
<th>Site of blood sample</th>
<th>Haematocrit level or above (%)</th>
<th>Risk of hyperviscosity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unwarmed heel</td>
<td>70</td>
<td>31</td>
</tr>
<tr>
<td>Warmed heel</td>
<td>65</td>
<td>71</td>
</tr>
<tr>
<td>Central venous</td>
<td>65</td>
<td>100</td>
</tr>
</tbody>
</table>

DISCUSSION

Haematocrit determinations are widely used in most neonatal units and it is important to have uniformity in the site, method and time of sampling. At birth a delay in cord clamping of 5 minutes, for example, can increase the blood volume by 61%, causing the haematocrit value to increase. These values show a greater variation over the following days.

The slight increase in venous haematocrit values from birth to 12 hours probably reflects changes in fluid balance over this period. Usher et al., in a study on the blood volume of the neonate, showed that similar changes occurred in the first 24 hours of life in babies whose cords were immediately clamped. When cord clamping was delayed, the haematocrit value increased considerably over that period. It is clear from Table I that when the heel is not warmed there is no correlation between the haematocrit value of blood so obtained and that of the venous or warmed heel prick samples. The haematocrit values observed in this study were within normal limits for newborn infants.

It is often difficult to obtain central venous blood from a newborn baby. Procedures such as femoral vein puncture or inserting a needle in the posterior fontanelle carry considerable risks and these methods are avoided as far as possible. The alternatives are arm, neck or scalp vein samples, but to obtain these may prove difficult. The good correlation between central venous and warmed heel prick haematocrit values and the use of the regression line and 95% confidence limits are useful for screening infants in whom polycythaemia is suspected. It must be pointed out that the warmed heel prick value does not exactly correspond to the venous value. A difference of as much as +8% and −3% was found between the two in this series. The method only serves as a guide as to which infants should have a venous blood sample taken. A difference of 26% was found between the unwarmed heel prick and venous haematocrit values, indicating the inaccuracy of the former method.

The assumption that an unwarmed heel prick haematocrit value of 70% or more is associated with polycythaemia is not necessarily correct. The blood flow in a cold foot is poor and sludging of red cells tends to give disproportionately high haematocrit values. In contrast, a haematocrit value of 65% or more in blood from a hyperaemic heel is associated with a considerable risk of hyperviscosity. The viscometer is a simple instrument to use but is not standard laboratory equipment — therefore Table II should prove useful in the management of babies with symptomatic polycythaemia. It is interesting to note that the blood of 1 infant with a venous haematocrit value of 63% was hyperviscous. A similar case was noted by Gross et al. and was thought to be related to maternal diabetes. No reason for the hyperviscosity could be found in our patient whose mother was not a diabetic.

The findings of this study make it clear that haematocrit values in the newborn are subject to variation. Standardization of the method of sampling and the significance of the results are important considerations.

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REFERENCES