HEMATOCRIT AND WHOLE BLOOD VISCOSITY IN NEWBORNS: ANALYSIS OF 100 CASES

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ABSTRACT

Hematocrit (Hct) and whole blood viscosity was studied at a mean age of ten hours in 100 neonates. Group A (n = 25), were term normal newborns, Group B (n = 25) were preterms, Group C (n = 20) were term small for gestation (SGA) and Group D (n =30) had perinatal hypoxia. Blood viscosity was estimated in all cases at shear rates 94.5, 51.2, 20.4 and 8.1 and intergroup variability in viscosity compared at shear rate 51.2. The mean hematocrity (Hct) (59.4%) and viscosity (8.2 cps) was higher in Group A as compared to other groups, but the difference was not significant ($p>0.05$). The upper limit of viscosity in Group C (11.9 cps) was higher than in all other groups but this difference was also not significant ($p>0.05$). With decrease in shear rates a reciprocal increase in viscosity was noted in all four groups. Seventeen neonates (17%) had polycythemia of which eight (47.5%) were SGA. Twelve per cent preterms were polycythemic. Only 3% of neonates had hyperviscosity. The mean Hct and viscosity of the 17 cases with polycythemia was 70.9 and 9.21 cps, respectively, which was significantly higher than mean Hct and viscosity of Group A ($p<0.05$). Partial exchange transfusions were done in five neonates with Hct >75%, of which only one had hyperviscosity. Post-exchange viscosity was not estimated. Whereas, three neonates with polycythemia were symptomatic, none of these had hyperviscosity. A linear correlation between Hct and viscosity was observed ($r = 0.67$).

Key words: *Hematocrit, Polycythemia, Viscosity, Hyperviscosity, Neonates.*

Hemorheology, a relatively new discipline of science concerns with the actual flow of blood within the vessels and depends principally on the quality of blood as a fluid(1). The neonate is particularly vulnerable to hemorheological alterations with an increased risk of sludging into the micro-circulation, resulting in impaired flow to various organs(2). Polycythemic and hyperviscous neonates are hence at risk of developing life-threatening complications such as, necrotizing enterocolitis(3), acute renal failure(4), hypoglycemia(5), hyperbilirubinemia(6) and cerebral vessel thrombosis(7). They also have a significantly greater risk of neurological impairment, specially when venous hematocrit (Hct) is >75%.

This study was designed to compare the

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mean, range and upper limits of Hct and whole blood viscosity in term normal, preterms and high risk neonates. An attempt was also made to ascertain whether polycythemia correlated with hyperviscosity and was predictive of a hyperviscous state. There have been very few reports in Indian pediatric literature on neonatal polycythemia(8-10) and none on neonatal blood viscosity, which prompted this study.

Material and Methods

Hematocrit (Hct) and whole blood viscosity were estimated within 24 hours of life, in 100 neonates over a two year period. In all cases the cord was clamped within one minute of delivery, with the baby held at level of mother's introitus. The neonates were divided into four groups:

Group A– 25 term normal neonates (controls)

Group B– 25 AGA preterms ≤34 weeks gestation.

Group C– 20 term SGA neonates.

Group D–30 term neonates with documented perinatal hypoxia(11).

Details of maternal history, delivery record, birth weight, gestation, resuscitation methods employed, clinical observation and relevant investigations were recorded in all cases.

Two ml of venous blood was collected avoiding excessive squeezing in an EDTA bulb at mean age of ten hours (range 6-12 hours), as physiologic hemodilution occurs after 12 hours age. The samples were then processed for Hct and blood viscosity. Hct was measured by a standard centrifuge, after spinning blood at 3000 rpm for five minutes. Blood samples were collected in EDTA and transported immediately in an ice box at 4°C to the School of Biomedical Engineering of the Indian Institute of Technology, Bombay, for viscosity studies done on a Contraves low shear 30 AG Zurich microviscometer. One ml of blood was sampled at 37°C and viscosity was estimated at shear rates (*i.e.*, velocity of flow at a given radius expressed as sec^{-1}) 8.1, 20.4, 51.2 and 94.5. Viscosity values were expressed in centipoise (cps). The mean, two standard deviations (2 SD) and upper limits of viscosity values at different shear rates were compared in the four groups and correlated with Hct.

Polycythemia was defined as venous Hct >65%(12) and hyperviscosity as values of >2 SD at atleast three different shear rates(12). Intergroup variability of blood viscosity was compared at shear rate of 51.2 and results expressed as mean ±2 SD. Low shear rates ranging from 8-12 mimics flow conditions in small venules, while higher shear rates of 90-115 mimics flow in large arteries(13).

Statistical comparisons were made using χ^2 test. Red cell aggregability and deformability, fibrinogen levels and blood volume estimation were not done.

Results

The mean Hct and viscosity of all 100 cases was 56.3% and 7.64 cps, respectively. The mean and range of Hct (%) of Groups A, B, C and D were 59.4 (44-81.4), 55.4 (39-70), 59.2 (40-76.6) and 52.8 (38-71), respectively. Although the mean Hct in Group A was higher than others, this difference was not significant ($p>0.050$). Mean, SD, upper limits of viscosity values of all four groups are shown in the *Table*. The upper limits of viscosity in Group A (controls) at shear rate 51.2 was 11.56 and hence values above this were taken as diagnostic of hyperviscosity. Mean viscosity

TABLE —*Mean, ±2 SD, and Upper Limits of Whole Blood Viscosity in Centipoise (Groups A, B, C, and D at Different Shear Rates)*

Shear rate in Sec $^{-1}$	Whole blood viscosity in centipose (CPS)			
	Group A (Control)	Group B (Preterm)	Group C (SGA)	Group D (Perinatal hypoxia)
94.5	6.75 ±2.81 (9.56)	6.16 ±2.66 (8.83)	6.9 ± 3.42 (10.33)	6.50 ±2.36 (8.86)
51.2	8.21 ±3.35 (11.56)	7.19 ±4.02 (11.22)	7.99 ±3.96 (11.95)	7.30 ±2.84(10.15)
20.4	10.78 ±4.68 (15.47)	9.05 ±5.78 (14.83)	9.63 ±5.54 (15.17)	8.50 ±4.24(12.75)
8.1	13.84 ±7.19 (21.03)	12.04 ±9.00 (21.04)	13.70 ±7.79 (21.50)	11.43 ±6.27(17.70)

Values in parentheses denote upper limits.

values of all four groups at different shear rates is depicted in *Fig. 1,* while the mean and range of viscosity at shear rate 51.2 in all four groups is shown in *Fig. 2.* The mean viscosity at shear rate of 51.2 in Group A was higher (8.21) than Group B (7.14), Group C (7.94) and Group D (7.30), but the difference was not statistically significant ($p>0.05$). Although the

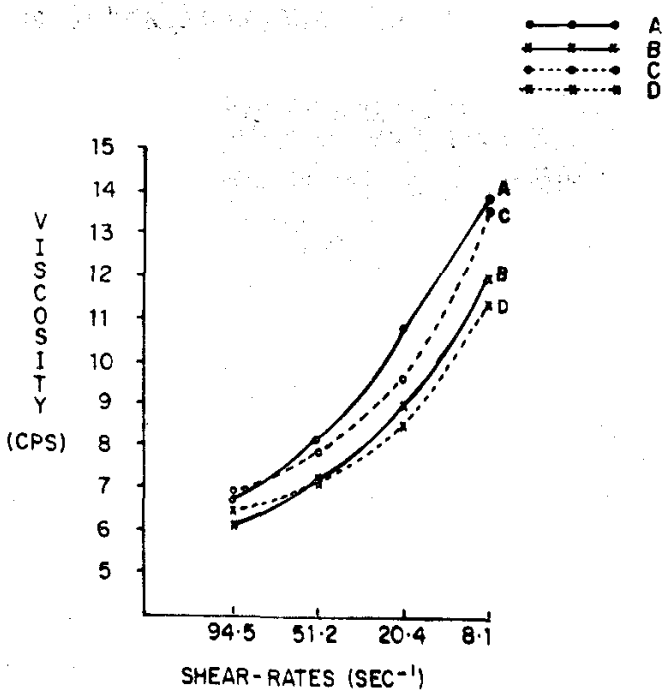

Fig. 1. Mean whole blood viscosity values of Groups A, B, C and D at different shear rates, showing increasing viscosity at decreasing shear rates.

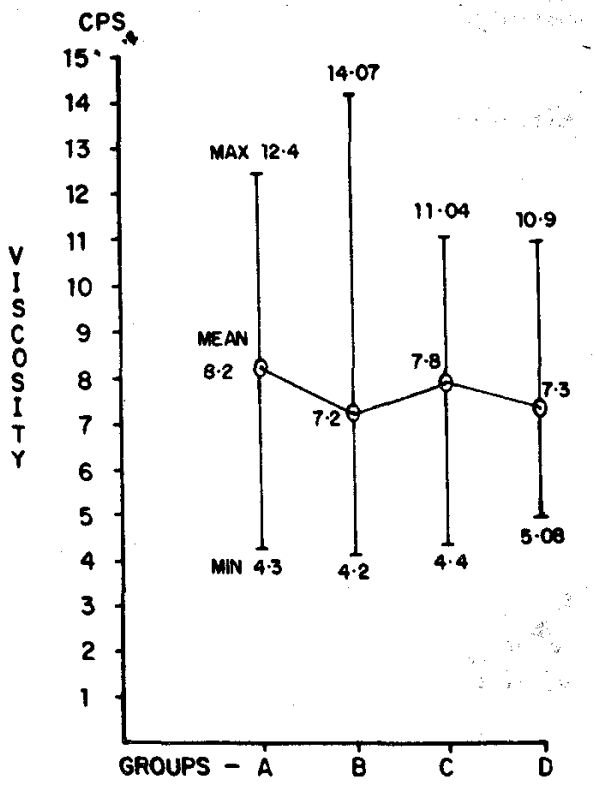

Fig. 2. Mean and range of viscosity values of groups A, B, C and D at shear rate of 51.2 sec^{-1} showing no significant inter-group difference ($p>0.05$).

upper limits of viscosity at shear rate 51.2 in Group C (SGA neonates) was higher (11.95) than Group A (11.56), Group B (11.22) and Group D (10.15), this difference was also not statistically significant ($p > 0.05$).

Seventeen neonates (17%) had polycythemia (Hct >65%). Of these four belonged to Group A, three to Group B, eight to Group C, and two to Group D. In Group C (SGA) the incidence of polycythemia was 40%. The mean Hct (70.9%) and mean viscosity (9.21 cps) in these 17 cases with polycythemia was significantly higher than mean Hct (59.4%) and mean viscosity (8.21 cps) of control Group A ($p < 0.05$). Of these 17 cases, only three (18%) had viscosity values > 11.5 cps at shear rate 51.2 and were hence diagnosed to be hyperviscous (*Fig. 3*). The viscosity of these three cases was >2 SD at atleast three different shear rates. Two cases of hyperviscosity were in Group A and one in Group B. Three of the 17 neonates with polycythemia were symptomatic of polycythemia and presented with plethora, jitteriness, and poor sucking although none of these had hyperviscosity.

In Group B and D, there were two deaths each, though these were not attributed to polycythemia. Partial exchange transfusion was done with saline, in those with Hct >75% (n = 5) as recommended(14). Post exchange viscosity was not estimated. Of the five neonates with Hct ≥75% only one was hyperviscous. As the mean and variability of Hct and viscosity in all the four groups was not significantly different, these values were correlated together in all 100 cases (*Fig. 4*). The linear coefficient of correlation r was 0.67 with standard error of 6.66.

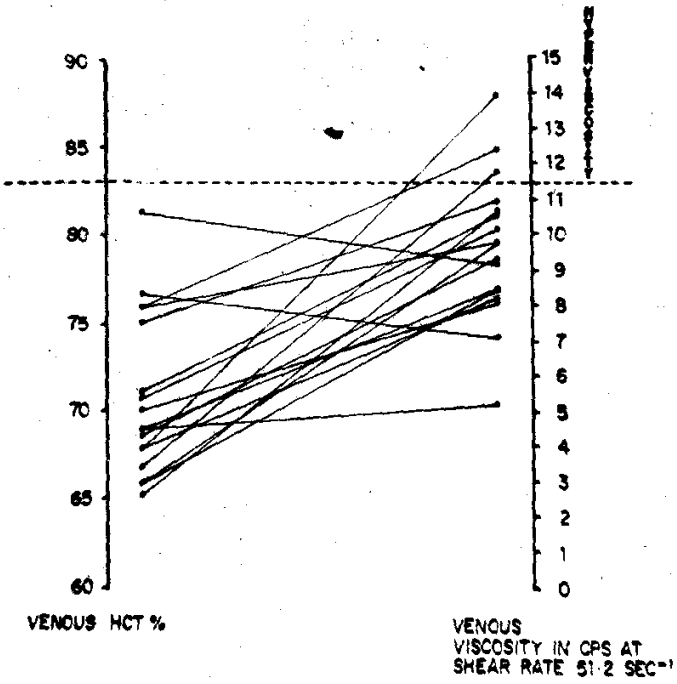

Fig. 3. Reciprocal values of hematocrit (Hct) and viscosity of 17 neonates with polycythemia.

Discussion

In vitro measurement of blood viscosity is the most sensitive method to estimate

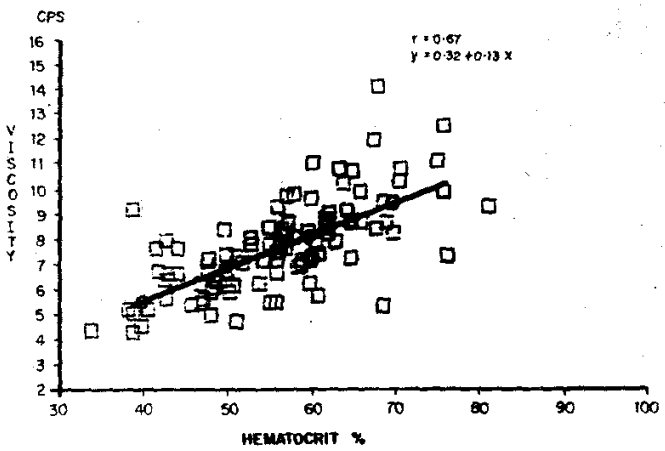

Fig. 4. Correlation between hematocrit (Hct) and viscosity of all 100 cases. Linear coefficient of correlation r = 0.67, y = 0.32 + 0.13 x.

microvascular sludging and risk of organ ischemia. In most nurseries viscosity measurements are not available and Hct values have to be relied on for the diagnosis of hyperviscosity. Although the terms hyperviscosity and polycythemia are frequently used interchangeably not all polycythemic neonates are hyperviscous and *vice vers*(15,16). Variables, affecting whole blood viscosity other than Hct and red blood cell defmormability are gestational age(15,17), time of clamping of cord(18) and neonatal blood volume(19). Although polycythemia is defined as venous Hct >65% there is still considerable controversy regarding the level at which intervention should take place(10). There is also difficulty in identifying Hct values that would be associated with hyperviscosity(20). Of 17 neonates with polycythemia, only 3 (18%) had hyperviscosity. Of the polycythyemic neonates eight were term SGA, three were preterms, four normal term and only two following perinatal hypoxia. The higher incidence of polycythemia in the present study as compared to other reports(9,10,21) may perhaps be due to inclusion of SGA neonates and also due to blood sampling at a mean age of 10 hours when there is significant hemoconcentration(18,22). Twelve per cent of preterms in this study were polycythemic, a finding which has also been recently reported in Indian literature(9,10).

Though 40% of SGAs (Group C) had polycythemia, the mean Hct in these was not significantly higher than in other groups, as reported by others(22,23). The mean viscosity increased with decreasing shear rates and there was no significant intergroup difference at any given shear rate (*Fig. 1*). The upper limit of viscosity at shear rate of 51.2 was also highest (11.95) in the term SGAs (Group C) although the intergroup differences of this value was not significantly different. Hct and viscosity increases with increase in gestational age and hence mature and post-mature babies are expected to have higher values(23). In the present study lowest mean viscosity values were seen in preterms as has also been noted by Lindercamp *et al.*(21). None of the neonates with perinatal hypoxia (Group D) who are supposedly at risk to develop hyperviscosity(24), were hyperviscous although two had polycythemia. Also the mean viscosity in Group D was lower than the controls Group A. Although eight out of 20 neonates in Group C (SGA) had polycythemia none was hyperviscous unlike other observations(25). In the present study no clinical or hemorheological follow-up was done to evaluate long term effects of polycythemia and hyperviscosity on neurological outcome. Therapeutic intervention was also not based on viscosity values as these were not available immediately.

On the basis of our results we concluded that it may not always be possible to predict a hyperviscous state even in presence of venous Hct >65%. As it is not possible to do viscosity estimations in most clinical laboratories the indication for therapeutic intervention must still be based on clinical observation and Hct values. The high overall incidence of polycythemia observed in our series (17%) was perhaps due to inclusion of heterogenous groups of neonates inclusive of SGA in whom we noted a high incidence (40%) of polycythemia. We were, however, surprised to find even a high incidence (16%) of polycythemia in the normal neonates (Group A). Although a linear correlation has been reported between Hct <65% and viscosity, this becomes exponential with Hct values >65%(12). In the present study we noted a

coefficient of correlation r = 0.67 which suggested that there was a linear correlation between Hct and viscosity. In the 17 neonates with polycythemia we noted a linear correlation with coefficient of correlation r = 0.92 between Hct and viscosity, however we did not observe an exponential correlation with Hct >65%. Further studies in larger number of patients are thus necessary to determine and correlate blood viscosity, specially in those with Hct >65% and also evaluate other variables particularly red blood cell deformability.

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NOTES AND NEWS

CME PROGRAMME ON PREVENTION AND CONTROL OF NOSOCOMIAL INFECTION IN HOSPITALIZED PATIENTS

Under the scheme for Continuing Medical Education with the Medical Council of India, approved by the Ministry of Health and Family Welfare, Government of India, a Continuing Medical Education Programme on 'Prevention and Control of Nosocomial Infection in Hospitalized Patients' is to be held at Christian Medical College, Vellore from *October 29-31, 1992,* in collaboration with American Association of Physicians from India and USA.

The Organizing Secretary is Dr. M.K. Lalitha, Professor of Microbiology, Christian Medical College, Vellore.