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Effects of Blood Donations on Haemorheology: A study on Blood Donors in Wurno Maternity Clinic, Babaldu.

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Abstract

Individuals donate blood for altruistic reasons or to their patients which are either their relatives or friends. Donation may be whole or part of blood by apheresis donation. The knowledge of the benefit or side effects of blood donation is paramount to blood donors. The aim of this study was to evaluate the possible benefit or side effects on blood donors through haemorheological indices. Blood sample of 116 apparently healthy, non-smoking, non-alcoholic, HIV 1 and 2, HCV, HBsAg and syphilis negative male blood donors aged 25 to 40 years with mean age 32 ± 8 years was studied. All the blood donors passed the minimum criteria for blood donation. Among the one hundred and sixteen whole blood donors, about 95% showed a significant decrease in relative plasma viscosity from the first day after blood donation throughout to the 7th day of post donation ($p < 0.05$). The haematocrit value also decreases after the donation. Blood donation is an excellent way to reduce the viscosity of blood which can be beneficial for the circulatory system by reducing the risk of heart disease.

Keywords: Blood, Viscosity, Plasma, Haemorheology.

Introduction

A blood donation occurs when a person voluntarily has blood drawn and used for transfusions and/or made into biopharmaceutical medications by a process called fractionation (separation of whole-blood components). Donation may be of whole-blood (WB), or of specific components directly (the

latter called apheresis). Many donors donate as an act of charity, but some are paid and in some cases there are incentives other than money such as paid time off from work. Donors can also have blood drawn for their own future use (autologous donation). Donating blood is relatively safe, but some donors have bruising where the needle is inserted or may feel faint. Blood donations are divided into groups based on who will receive the collected blood. An allogeneic (also called 'homologous') donation is when a donor gives blood for storage at a blood bank for transfusion to an unknown recipient. A 'directed' donation is when a person, often a family member, donates blood for transfusion to a specific individual. Directed donations are relatively rare when an established supply exists. A 'replacement donor' donation is a hybrid of the two and is common in developing countries (Reid and Ugwu, 1987). In this case, a friend or family member of the recipient donates blood to replace the stored blood used in a transfusion, ensuring a consistent supply. When a person has blood stored that will be transfused back to the donor at a later date, usually after surgery, that is called an 'autologous' donation.

Viscosity of blood is a measure of the resistance of blood to flow. It can be described as the thickness and stickiness of blood. This dynamic biophysical property of blood makes it a critical determinant of friction against the vessel walls, the rate of venous return, the work required for the heart to pump blood and how much O₂ is transported to tissues and

organs. Blood is a non-Newtonian fluid; as such the viscosity of blood varies with shear rate. Shear rate can be thought of as a velocity gradient. Unbalance forces such as pressure gradients in the vasculature due to continues deformation of the blood cells, causing adjacent layers of the blood to slide past each other at a certain velocity altering its shear rate. When shear rate increases, a tangential force called shear stress acts against blood vessel walls. Blood becomes physically thinner at high shear rates like those experienced in a peak-systole. Contrarily, during end diastole, blood moves slowly and becomes thicker and thicker. Blood is a shear thinning fluid because its velocity decreases as shear rate and shear stress increases. The primary determinants of blood rheological properties are haematocrit, red cell deformability, red cell aggregation and plasma viscosity (Letcher et al., 1981). Haematocrit has the greatest impact on blood viscosity. One unit increase in haematocrit can cause up to 4% increase in blood viscosity (Brown, 1998; Baskurt et al 2003). This relationship becomes increasingly sensitive as haematocrit increases. When the haematocrit rises to 0.6 to 0.7 which it often does in polycythaemia (Tefferi, 2003). Blood viscosity can become as great as ten times that of water and its flow through blood vessels is greatly retarded because of increased resistance of flow (Jeong et al., 2010), which will lead to decreased oxygen delivery (Fowkes et al., 1993). Consequently, blood viscosity has been established as a major determinant of the work of the heart and tissue perfusion (Lenz et al., 2008).

Increased viscosity requires a higher blood pressure to ensure the same circulating volume of blood, both the burden on the heart and the forces acting on the vessel wall are directly modulated by changes in blood viscosity. In the Edinburgh Artery Study (1993), which followed 1,592 randomly selected adults, demonstrated that systolic blood pressure (BP) was univariately related to blood viscosity in males only ($p < 0.001$), and diastolic blood pressure

was univariately related to blood viscosity in both gender ($p < 0.001$). Haematocrit-corrected blood viscosity levels were also significantly related to systolic and diastolic blood pressure in both sexes (Contreras et al., 2005).

Another study shows a direct correlation between Blood Pressure and blood viscosity among both normotensive and hypertensive subjects ($p < 0.001$) (Contreras et al., 2005). Systolic blood viscosity was 8 to 10% higher in hypertensive patients compared with normotensive controls, and diastolic blood viscosity was 16 to 28% higher in hypertensive patients. Subgroups each comprised of 25 subjects having matched haematocrits were also compared, and viscosity remained significantly higher in hypertensive subjects ($p < 0.05$) (Kwon et al., 2008). In Pascal-seconds (Pa.s), the viscosity of blood at 37°C is normally 3×10^{-3} to 4×10^{-3} respectively and 3 to 4 centipoise (cP) in the centimetre gram second system of units (Elert, 2010). This study was undertaken to determine haemorheological activity using relative plasma viscosity in apparently healthy blood donors.

Material and methods

This study was carried out with the approval of the Wurno Medical Centre between September, 2008 and December, 2009. Verbal informed consent was obtained from each of the 116 apparently healthy, non-smoking, non-alcoholic, HIV 1 and 2, HBsAg, HCV, syphilis negative male blood donors aged 25 to 40 years and mean age 32 ± 8 years drawn from Jigawa environs were obtained. For each test 2 ml of blood was withdrawn from each subject and added to dipotassium EDTA anticoagulated tube to give a final concentration of 1.5mgml^{-1} for the determination of plasma viscosity. Plasma viscosity was determined using a standard method (Reid and Ugwu, 1987). In the calculation of relative plasma viscosity (RPV), the mean values of the flow rates of plasma and distilled water in seconds were applied using the following equation;

$$\text{Relative plasma viscosity} = \frac{\text{flow rate of plasma (second)}}{\text{flow rate of distilled water (second)}}$$

Data were expressed as mean \pm standard deviation. The difference between means was considered statistically significant when $p \leq 0.05$.

Result

Table 1 shows relative plasma viscosity and haematocrit before donations and 30minutes, 1 day, 3 days, 5 days and 7 days post blood donations. The

average relative plasma viscosity before phlebotomy and seventh day after were 1.98 ± 0.29 and 1.55 ± 0.22 respectively. There was no statistical differences in the mean plasma viscosity pre-donation and 30 minutes post donation ($p > 0.05$). There were statistically significant differences in the mean plasma viscosity pre-donation and 1, 3, 5 and 7 days post donation ($p < 0.05$). Table 2 shows the

changes in mean relative plasma viscosity before and up to 7 days post blood donations. The average haematocrit before phlebotomy and seventh day after

were 0.44 ± 0.06 and 0.41 ± 0.05 respectively. Figure 1 shows a graphic relations between the relative plasma viscosities versus time.

Table 1: Mean relative plasma viscosity and Haematocrit before and after blood donations

Time	Pre donation	30 th minute after donation	1 st day after donation	3 rd day after donation	5 th day after donation	7 th day after donation
Mean relative plasma viscosity \pm SD	1.98 ± 0.29	1.97 ± 0.29	1.65 ± 0.2	1.59 ± 0.2	1.56 ± 0.21	1.55 ± 0.22
Haematocrit \pm SD	0.44 ± 0.06	0.41 ± 0.04	0.40 ± 0.03	0.40 ± 0.05	0.41 ± 0.03	0.41 ± 0.05

Table 2: Changes in mean relative plasma viscosity before and up to 7 days post blood donations

Time	Pre donation	Post donation	p- value
Post 30 Minutes	1.98 ± 0.29	1.97 ± 0.29	>0.05
Post 1st Day	1.98 ± 0.29	1.65 ± 0.2	<0.05
Post 3rd Day	1.98 ± 0.29	1.59 ± 0.2	<0.05
Post 5th Day	1.98 ± 0.29	1.56 ± 0.21	<0.05
Post 7th Day	1.98 ± 0.29	1.55 ± 0.22	<0.05

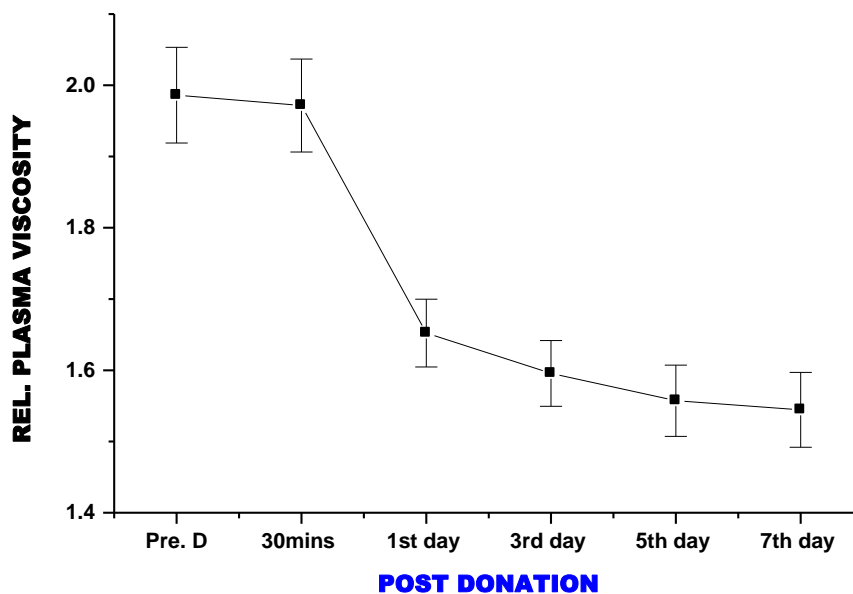


Figure 1: Mean Relative Plasma Viscosity versus time (days) of post donation

Discussion

Blood donation seems to affect haemorheological properties and haematocrit level. Relative plasma viscosity are influenced by haematocrit (packed cell volume), red cell aggregation and red cell deformability, of these haematocrit has the strongest impact (Baskurt et al., 2003).

One unit increase in haematocrit can cause up to 4% increase in blood viscosity (Baskurt *et al.*, 2003). This relationship becomes increasingly sensitive as haematocrit increases. When the haematocrit rises to 0.6 to 0.7, which is often does in polycythaemia (Tefferi, 2003) the blood viscosity can become as great as 10 times that of water & its flow through blood vessels is greatly retarded because of

increased resistance to flow (Jeong et al., 2010). This will lead to decreased oxygen delivery (Fowkes *et al.*, 1993). Many conventional cardiovascular risk factors and outcomes have been correlated with blood viscosity. Hypertension, total cholesterol, LDL cholesterol, triglycerides, chylomicrons, VLDL cholesterol, diabetes & metabolic syndrome, obesity, cigarette smoking, male gender and aging were all being positively correlated to blood viscosity. HDL cholesterol has been negatively correlated to blood viscosity (Dorman, 1981).

This study shows that relative plasma viscosity decreases significantly from 30th minutes post blood donation throughout to the seventh day ($p < 0.05$). While the haematocrit value also decreases as expected from a level before donation to a lower level after donation.

Conclusively, the study suggest that there were significant changes in plasma viscosity following blood donation. The recommendations that can be offered at this juncture are that blood donors would probably benefit if they can donate blood regularly. Monitored blood donation may be considered a treatment modality for coronary heart disease. This study also opens up further avenue for research in a prospective manner for more definitive result.

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