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Letter to the Editor

Influence of lipids on blood and plasma viscosity

Amparo Vayá[a,*], Cristina Giménez[a], Rafael Alis[b,c], Julian Murado[a] and Óscar Fuster[a]

[a]*Hemorheology and Haemostasis Unit, Service of Clinical Pathology, La Fe University Hospital, Valencia, Spain*

[b]*Research Universitary Institute "Dr. Viña Giner", Molecular and Mitochondrial Medicine, Catholic University of Valencia "San Vicente Mártir", Valencia, Spain*

[c]*Faculty of Medicine, Catholic University of Valencia "San Vicente Mártir", Valencia, Spain*

In a recent paper by Irace et al. [2] published in Clinical Hemorheology and Microcirculation, the influence of lipids on plasma and blood viscosity in healthy subjects was analysed. The authors found that HDL-cholesterol and LDL-cholesterol moderately influenced plasma viscosity, but not blood viscosity, and that triglycerides did not seem to have a major effect on both viscosity parameters. In this study, the authors did not determine fibrinogen, which is of paramount importance in rheological blood behaviour. Moreover, it is usually reported that plasma lipids and fibrinogen levels are closely related [3–6], thus not having determined fibrinogen may influence the results reported by Irace et al.

To further clarify this issue, in 1,002 healthy subjects (493 men and 509 women) attending the Preventive Medicine Service at our hospital, we investigated the effect of BMI, waist, glucose, plasma lipids and fibrinogen on rheological parameters such as plasma viscosity, blood viscosity at native and at 45% corrected haematocrit, and Erythrocyte Elongation Index at 60 Pa (EEI60), as previously performed [5].

Several partial correlations were found between rheological and biochemical parameters (Table 1). Multivariate analyses showed that T-cholesterol, triglycerides and fibrinogen were independent predictors of plasma viscosity, and that waist, haematocrit and EEI60 independently predicted native blood viscosity, while fibrinogen and triglycerides were independent predictors of corrected blood viscosity (Table 2). Irace et al. [2] did not measure fibrinogen, whereas we show that it has a strong influence on plasma viscosity. Therefore, it should be determined and included in the multivariate regression analysis to explore the determinants of plasma viscosity.

Regarding native blood viscosity, haematocrit exerts the greatest influence, followed by waist and EEI60. In a previous study [5], we evaluated waist and BMI influence on rheological factors, and we

*Corresponding author: Amparo Vayá, MD, PhD, Hemorheology and Hemostasis Unit, Service of Clinical Pathology, La Fe University Hospital, Avda. de Campanar, 21, 46009, Valencia, Spain. Tel./Fax: +34 963862714; E-mail: vaya_amp@gva.es.

Table 1
Pearson's bivariate correlations among BMI, w, biochemical parameters and rheological variables

	Plasma viscosity ($n = 956$)	Native blood viscosity ($n = 868$)	Corrected blood viscosity ($n = 716$)
BMI	0.240**	0.178**	0.082*
Waist	0.113*	0.408**	0.040
Glucose	0.126**	0.162**	0.086*
T-cholesterol	0.208**	0.114**	0.104**
HDL-cholesterol	0.054	−0.253**	−0.074
LDL-cholesterol	0.189**	0.190**	0.075
Triglycerides	0.168**	0.198**	0.131**
Fibrinogen	0.490**	−0.054	0.119**
Haematocrit	0.034	0.753**	0.045
EEI60		−0.109**	−0.126**

EEI60: Erythrocyte Elongation Index at 60 Pa.* $p < 0.05$, ** $p < 0.01$.

Table 2
The standardised β coefficients obtained in the multivariate regression analysis

	Plasma viscosity ($n = 956$)	Native blood viscosity ($n = 868$)	Corrected blood viscosity ($n = 716$)
Waist		0.099*	
T-sholesterol	0.148**		
Triglycerides	0.147**		0.115**
Fibrinogen	0.465**		0.124**
Haematocrit		0.716**	
EEI60		−0.108**	

EEI60: Erythrocyte Elongation Index at 60 Pa.* $p < 0.05$, ** $p < 0.01$.

showed that waist plays a more important role in blood viscosity than BMI. In another study on morbidly obese, we also demonstrated an inverse relationship between waist and EEI60 since abdominal fat is a metabolically active organ that releases free fatty acids, hormones and adipokines, which may modify this parameter [1–4].

In summary, fibrinogen and lipids are the main determinants of plasma viscosity and corrected blood viscosity, whereas haematocrit, erythrocyte deformability and waist play a key role in native blood viscosity.

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