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Blood Viscosity and Finger Systolic Pressure in Primary and Traumatic Vasospastic Disease

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ABSTRACT

Vasospastic reactions to cold have been suggested to be related to altered blood rheology, as has been reported in both primary (PVD) and traumatic (TVD) vasospastic disease.

Measurements of whole blood viscosity , plasma viscosity , erythrocyte deformability and finger systolic pressure (FSP) were performed in 18 patients with PVD (Raynaud´s disease) and 15 patients with TVD.

FSP at 10 °C was significantly lower in both patient groups than in a normal reference group. All rheologic variables at 37 and 10 °C were normal, apart from increased erythrocyte deformability at 37 °C in the PVD group.

INTRODUCTION

The pathogenesis of the vasospastic reaction to cold and vibrating tools has not yet been fully established. In the diagnosis of vasospastic disease, the cold provocation test is considered to be of value. The viscosity of the blood has been reported to be increased both in primary (PVD) and in traumatic (TVD) vasospastic disease (3, 4, 9), but at least in PVD there have also been reports on unchanged blood viscosity (2, 6, 10).

In the present study the blood viscosity , erythrocyte deformability and finger systolic pressure (FSP) were measured in two groups of patients, one group with PVD and another with TVD, without any symptoms or laboratory signs of collagen disease.

MATERIAL AND METHODS

Patients with primary vasospastic disease

Eighteen patients, 14 women aged 21–60 years and four men aged 25–49 years, were selected on the basis of a typical history of PVD (1). None of the patients had acute infectious disease, or a history involving the use of vibrating tools, or of collagen disease, as excluded by S-acryl, S-ANF and S-electrophoresis tests. Three of the patients were smokers.

Patients with traumatic vasospastic disease

Thirty-seven men, aged 21-65 years, who had been exposed to vibrating tools for at least 15 years, were admitted from the Department of Occupational Health to our laboratory. Most patients were investigated during the period of exposure, but some were investigated a few years after they had stopped using vibrating tools. Thirteen of these patients were smokers. In patients in whom collagen disease could not be excluded by the history, the same tests as in the PVD group were performed in order to rule out this possibility. As in the PVD group patients with acute infectious disease were excluded.

Finger systolic pressure measurements

FSP was measured during cooling to 30 ^{o}C and then to 10 ^{o}C, using a finger plethysmograph (Model SB 2, Medimatic, Copenhagen, Denmark) with a fluid-perfused cuff at a pre-set temperature (5, 7, 10, 11). In the PVD group FSP measurements were performed in digit 4 on both hands, and in the TVD group digits giving symptoms of vasospastic reaction were investigated.

FSP is expressed as FSP %, calculated as the finger systolic pressure at 10 ^{o}C in per cent of that at 30 ^{o}C for the same finger, corrected for changes in arterial pressure (7).

Erythrocyte volume fraction and blood rheology

Venous samples for rheologic analyses and measurements of the erythrocyte volume fraction (EVF) were drawn into heparinised vacuum tubes (Terumo venoject) after the patient had rested for 15 minutes. EVF was measured by centrifugation in microhaematocrit tubes, without correction for trapped plasma (trapping was estimated at 1 %). Whole blood viscosity, plasma viscosity and erythrocyte deformability were determined at 37 and 10 ^{o}C in a Low Shear 30 couette rotational viscometer (Contraves AG, Zürich, Switzerland). A temperature of 10 ^{o}C was chosen to match the FSP cold test.

Whole blood apparent viscosity (B-viscosity) was measured at a shear rate of 100 s^{-1} and corrected to a standard EVF of 45 %, assuming a linear relationship between EVF and the logarithm of viscosity. Plasma viscosity (P-viscosity) was determined at a shear rate of 37.6 s^{-1}.

Erythrocyte deformability was measured as the inverse apparent viscosity at a shear rate of 0.945 s^{-1}. Isotonic saline-phosphate-glucose buffer at pH 7.4 was used to wash and resuspend the erythrocytes to an EVF of 55 %. Deformability was expressed as apparent fluidity of erythrocytes (E-fluidity), using the unit $Pa^{-1} \cdot s^{-1}$.

Statistical methods

Student's unpaired t-test was used.

RESULTS

Finger systolic pressure

As there was no significant difference in FSP % between men and women or between the left and right hand, in the PVD group, the values from all 18 patients were pooled and the mean of the left and right hand was calculated. In the TVD group the mean of the FSP % values from the most affected digit in each patient was used for comparisons. There was no significant difference in FSP % between the PVD and TVD groups, but both groups differed ($p<0.001$) from a reference group of normal subjects (11) (Table 1).

Table 1 Finger systolic pressure (FSP) at 10 °C in per cent (mean value and SD) of that at 30 °C for the same finger in three different groups of patients.

	FSP %	SD	n	
PVD group	61	29	18	(14 women, 4 men)
TVD group	57	35	37	(37 men)
Reference group	90	11	56	(33 women, 23 men)

Rheology

Rheologic variables were determined in all of the PVD patients and in 15 of the patients with TVD (Table 2). In 22 patients of the TVD group only FSP % was determined, since rheologic tests had not previously been performed as routine in vasospastic disease at our laboratory.

The erythrocyte deformability at 37 °C (expressed as E-fluidity) was significantly better in the PVD group than in the TVD group ($p<0.05$), and also better than in the reference group. The difference in EVF between the PVD and TVD groups was probably due to the difference in sex distribution. Apart from these divergences there was no difference between the three groups in any variable.

Table 2 Mean value and SD for the rheologic variables whole blood (B) apparent viscosity, plasma (P) viscosity and apparent fluidity of erythrocytes (E) measured at 10 and 37 °C, and erythrocyte volume fraction at room temperature, in three different groups of patients.

Variable	PVD group (n = 18) Mean	SD	TVD group (n = 15) Mean	SD	Reference group (n = 10) Mean	SD
B-viscosity, 37 °C*	4.69	0.21	4.75	0.28	4.52	0.29
B-viscosity, 10 °C*	12.1	1.7	11.3	1.0	11.1	0.9
P-viscosity, 37 °C*	1.27	0.07	1.31	0.07	1.28	0.07
P-viscosity, 10 °C*	2.71	0.46	2.95	0.43	2.70	0.19
E-fluidity, 37 °C**	123	11	115	10	116	7
E-fluidity, 10 °C**	68	7	65	6	67	4
EVF (%)	40.9	4.5	45.1	2.1	41.9	3.0

* (mPa · s), ** ($Pa^{-1} \cdot s^{-1}$)

DISCUSSION

In addition to typical clinical symptoms of vasospastic disease, the selected PVD and TVD patients also showed an objective sign of this disorder, namely significantly lower FSP % at a cold provocation test (Table 1). The present study demonstrated that in the PVD patients (n = 18) the whole blood viscosity and plasma viscosity were unchanged at 10 and 37 °C. The erythrocyte deformability (fluidity) was increased at 37 °C but not at 10 °C. In the TVD group (n = 15) the values for whole blood viscosity, plasma viscosity and erythrocyte deformability at 10 and 37 °C were normal as compared with a reference group (n = 10). These results are in accordance with some other blood rheologic findings (2, 6, 10). Other authors have however found increased whole blood viscosity at high and low shear rates and at temperatures from 22 to 37 °C in PVD (3, 4, 9) and in TVD (3).

To ensure a true vasospastic reaction and detection of possible changes in rheology, we used a temperature of 10 °C in the cold provocation test as well as in the rheologic analyses.

As far as we know no other author has studied erythrocyte deformability in primary and traumatic vasospastic disease. The increased fluidity at 37 °C in the PVD group might be explained by enhanced deformability. Such a change would facilitate rather than hinder peripheral circulation.

This difference in fluidity at 37 °C might be of value as a tool in the differential diagnosis between PVD and TVD. On the other hand, the difference in sex distribution between the two groups might explain the results. Further investigation of this matter is therefore required.

Other rheologic variables are, in our opinion, of no value in the diagnosis of vasospastic disease - either primary or traumatic.

Pola et al (8) observed a decrease in whole blood viscosity in PVD patients after cold provocation tests. It would therefore be of interest to study the blood rheology during the onset of a vasospastic attack.

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