The effect of viscosity and velocity on blood flow for Diabetic Mellitus disease

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Abstract

Blood viscosity is a measure of the resistance of blood to flow. It can also be described as the thickness and stickiness of blood. . To determine the relation between viscosity and velocity of blood for DM patient , the samples tests from patients have glucose 119 to 333mg/dl by using Ostwald viscometer with diameter 0.5 mm.

The results proved the viscosity was increased with increased glucose ,but the velocity of blood was reduced with increased viscosity to patients and the ratio of the viscosity in the blood of Victims of diabetes increases with the increase in the rate glucose in the blood while the blood velocity decreases with increasing the proportion of glucose in the blood.

INTRODUCTION

It is necessary to known the viscosity of liquids. Viscosity is the measure of the liquid's resistance to flow. Liquids with high viscosity have greater resistance to flow and are not readily deformed by physical stress, while liquids with low viscosity are "thin" and flow easily. Viscosity of liquids can be calculate by using an instrument known as a viscometer[1].

Blood flow velocity as given in the medical dictionary its define "A value represent to the total volume flow divided by the cross-sectional area of vascular bed". Blood flows inside our body under a certain velocity and pressure. The velocity of blood is a measurable factor and its value depends on the health status of an individual The human body is made up of several processes all carrying out various functions Blood accounts for 8% of the human body weight, with an average density of approximately 1060 kg/m^3, very close to pure water's density of 1000 kg/m^3. The blood composed of plasma and several kinds of formed elements of the blood are erythrocytes (red blood cells, RBCs), leukocytes (white blood cells), and thrombocytes (platelets). It's exhibits non-Newtonian, viscoelastic fluid dynamics; its flow properties are adapted to flow effectively through tiny capillary blood vessels with less resistance than plasma by itself.

Increased blood viscosity is the only biological parameter that has been linked with all of the other major cardiovascular risk factors, including high blood pressure, elevated low –density lipoprotein LDL cholesterol and low high –density lipoprotein HDL, type-II diabetes which finding metabolic syndrome, obesity, smoking, age, and male gender [2].

Lowe et al.,(1997) who was interesting is that these findings were based solely on measuring systolic blood viscosity (that is, high shear rate viscosity), where the variation range is very narrow. Even so, the link between systolic blood viscosity and cardiovascular disease events was statistically as strong as the links between diastolic blood pressure and LDL cholesterol on one hand, and cardiovascular events on the other. The association between systolic viscosity and cardiovascular events was stronger than that between smoking and cardiovascular events[3]

In a prospective study, 331 middle-aged men with high blood pressure were followed for up to 12 years after measuring diastolic blood viscosity (i.e., low shear rate viscosity). The subjects were divided into three groups according to viscosity levels: those in the highest viscosity group had more than three times more cardiovascular events than those in the lowest viscosity group (hazard ratio = 3.42, 95% confidence interval 1.4–8.4, p = 0.006), [4].

In a study of 128 obese people (BMI > 28 kg/m^2) and 90 non-obese healthy controls, diastolic blood viscosity was 15% higher in obese vs. non-obese patients [5]. Numerous other studies have also shown that type-II diabetics have higher systolic and diastolic viscosity than healthy non-diabetic people.

Many studies have linked cholesterol with blood viscosity; LDL is consistently associated with higher blood viscosity, while HDL is associated with lower viscosity [6].

Blood viscosity has been established as a major determinant of the work of the heart and tissue perfusion [7]

John (1971) Who proved Changes in whole blood viscosity are related to changes in the leg blood flow during infusions of low-molecular-weight Dextran. A close inverse correlation exists between changes in viscosity and blood flow, the change in blood flow being about three times greater than the change in blood viscosity. [8]

Simple viscometer that is used in laboratory settings is the Ostwald viscometer, also known as the glass capillary viscometer .

the amount of time it takes for a liquid to flow past the two marks, and the density of that liquid.

Theory

The velocity (v) is the rate of change of the position of an object with time.

$$v=x/t ....(1)$$

Where v : is the dynamic velocity. t: is the time of drop of fluid. x: is the distance from A to B (cm/sec) as shown in fig(1).

U-tube viscometer U-shaped glass tube device consists of two bulbs, one on the lower part of the left arm , and the other on the high part of the right. It is held vertically as the liquid is drawn up into the upper bulb and then allowed to flow back down to the lower bulb, past two marks on the tube.

To determine the density of a liquid (ρ: is the density of fluid) using the following equation:

$$ρ =m/V ....(2)$$

Where V is the volume of (ml), , m=mass of blood glucose (gm).

Blood viscosity measurements in cylindrical tube viscometers have to calculate the viscosity of blood (η)use the following eq.

$$η = ρ *t ....(3)$$

where η is the dynamic viscosity (gm.sec/ml).

t is the time of drop of fluid in eq.(3).

Velocity of blood flow is determined by a factor known as Reynolds number (Re). The Reynolds number represents the ratio of the importance of inertial effects in the flow, to viscous effects in the flow ,the formula is stated below [9],[10]:

Re = (mean velocity× vessel diameter× blood density)/blood viscosity.(4)

So, when the Reynolds number is below 2.300 , we can expect the flow to be laminar, and when it is above approximately 4.000, the flow will be turbulent. In between these two limits, the flow is termed "transition flow[11]

Materials and Method

Used a container cover tube to put the blood of diabetic patient ages(44,30,27,37,54) year had glucose level at (119, 126, 179, 247, 333)mg/dl. patients in this group were not associated with diabetic foot complications after full clinical exam by peripheral pulses or intact peripheral pulses of foot . They had no smoking or alcohol drinking for all patients   .Patients were free of acute illness or infection at time of study and exclusion criteria such as hemolytic Anemia, pregnant women, hypertension, severe Arthritis , hypothyroid ,liver and kidney disease also those   with known Anti hypertension ,Anti platelets , Anti lipid and Anti diabetic.

Before the procedure kits (Ostwald viscometer and graduated cylinder) were cleaned especially glassware instruments. After that, the assay was carried out the steps following:

Clamp the clean and dry viscometer vertically using iron stand. These weights of blood were calculated by using sensitive balance.

Add a blood of DM patient in the tube from the biological lab. in the centre of diabetes mellitus drop into a large graduated cylinder to measure the volume in ml after determine the mass of blood . then , put the blood in the Ostwald viscometer and force the blood by means the rubber tube. Release the pressure, thus allowing the blood to flow throw the capillary and record the time taken to pass between marks A and B as appears in the figure(1).
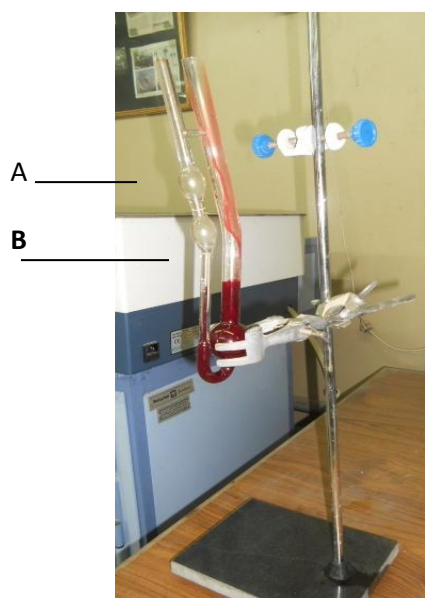
A _____

B _____

Figure (1) experimental determine blood velocity and viscosity

Results and Discussion

To determine the density of a blood using equation(2) and calculate the viscosity of blood, while has been worked in the chemical physics laboratory and used Ostwald viscometer for test from eq.(3). Determine the relation between viscosity and velocity of blood for DM patient ,we choice the samples from patients have glucose 119 to 333mg/dl at by using Ostwald viscometer was diameter 0.5 mm ,results be noted in table (1). Limit the Reynolds number (Re) according eq.(4) as shown in table (2).

Table (1) Arrange the data   determine viscosity and velocity of DM patients

| No.	Glucose	Mass(g)	X(cm)	t (sec)	Volume (ml)	ρ(g/ml)	η(g.sec/ml)	Velocity (mm/s)
1	119	2.8	3	60	2.6	1.07923	64.56	0.5
2	126	3.3	3	72	2	1.65	118.8	0.41666
3	179	3.4	2	90	2.2	1.5454	139.09	0.2222
4	247	3.28	2	114	2	1.64	186.96	0.17543
5	333	2.98	2	120	2	1.49	178.8	0.16666

Table (2) represent change of Reynolds number patient's blood test with glucose level.

No.	Glucose(mg/dl)	Reynolds number (Re)
1	119	4.1047
2	126	1.858561
3	179	0.84668
4	247	0.4973
5	333	0.490145

As shown in figure(2- A) the velocity decreased with increase glucose. The increase viscosity with increasing glucose (table 1), In contrast was noted inverse relation between viscosity and average velocity in the figure (2- B) .the viscosity was increased with increased glucose ,but the velocity was reduced with increased viscosity of patients.

velocity blood vs. glucose level of DM Patients

$y = - 1.3e{-}007*x^3 + 0.0001 \quad ?6*x + 2.3$
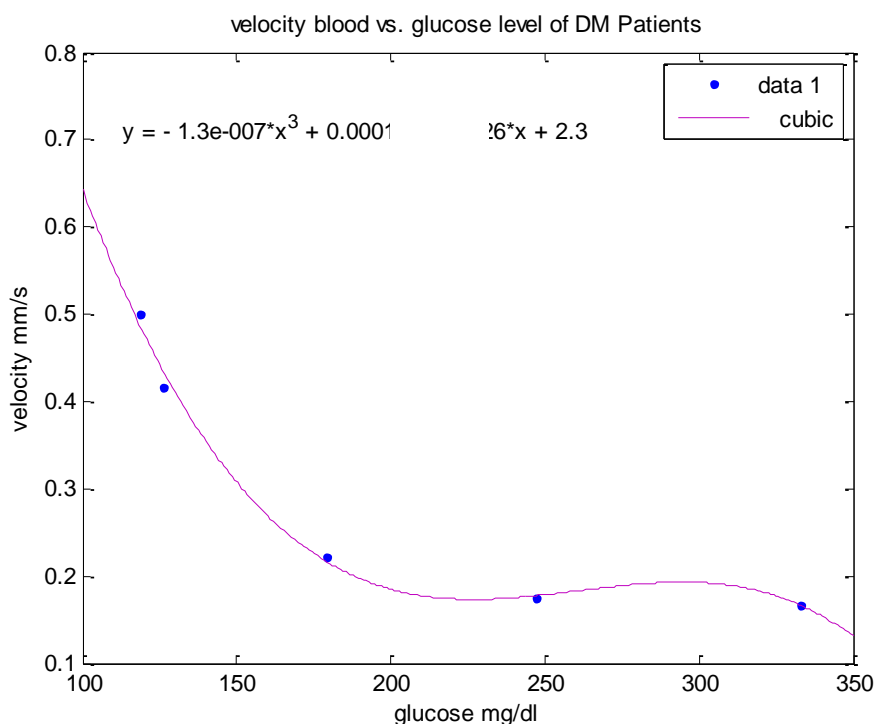
(A)
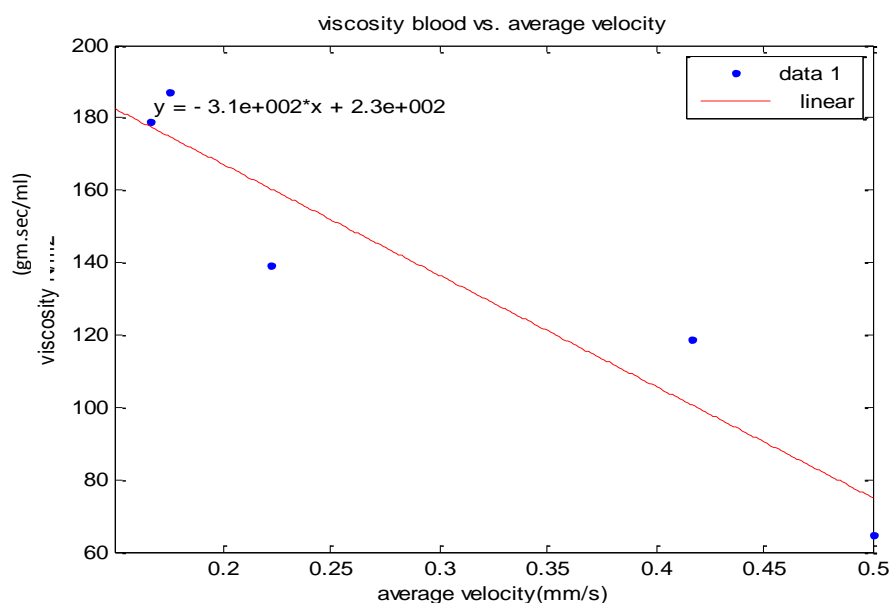
(B)

Figure (2) Relation (A) average velocity vs. glucose level
(B) viscosity with average velocity to DM patient .

Conclusions

One of the most factor influence of blood flow is viscosity .when the glucose level of diabetic patient are increase ,the density of blood is increase so the viscosity increase too. The cause of decrease of velocity of blood flow from diabetic patients was increasing of viscosity with high degree of glucose level. High thick of blood from diabetic patients becomes low blood flow. That the nature of a fluid flow can be completely different depending on the Reynolds number. Reynolds numbers, which depends on velocity of blood and viscosity. So decrease of Reynolds numbers with increase glucose level of diabetic patient proved start problems of the pumping action of the heart, or narrowing of blood vessels can have many consequences including hypoxia (lack of oxygen) of the tissues supplied. The term ischemia refers to tissue that is not inadequately blood flow

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الخلاصة

لزوجة الدم هي مقياس لمقاومة تدفق الدم. يمكن وصفها ايضا بانها مقدار سمك الدم. لتحديد العلاقة بين اللزوجة وسرعة الدم لدى مرضى داء السكري، تم اختبار عينات المرضى الذين لديهم نسبة الكلوكوز119−333 ملغرام/دسي لتر باستخدام جهاز قياس اللزوجة وستوالد بقطر 0.5 ملم

اثبتت النتائج زيادة اللزوجة مع زيادة نسبة الكولكوز ولكن تنخفض سرعة الدم مع زيادة اللزوجة ونسبة اللزوجة في الدم لدى مصابي داء السكري تزداد مع زيادة معدل الكولكوز في الدم في حين ان سرعة الدم تقل مع زيادة نسبة الكولكوز في الدم.