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A Review on Blood Viscosity and Its Influence on Blood Pressure

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Abstract: Nature depends on liquids; nature of liquids is to exert pressure. Blood is also a liquid, pressure exerted by blood on walls of blood vessels is called blood pressure. This concept of blood pressure is influenced by a new concept called blood viscosity. Blood viscosity measures the potential of blood with which it circulates in the blood vessels. Alteration in blood pressure mimics blood viscosity, which influences peripheral resistance of arteries. The main work in this paper involves case studies which gives the participation of blood viscosity in patients who encountered heart problems and reveals blood viscosity as an influential factor among obese and non- obese people. “THE STRONG HEART STUDY” gives a clear vision regarding blood viscosity related health disorders in humans. This also discloses the relation between blood viscosity and hematocrit.

Index Terms: Blood Pressure, Blood viscosity, hematocrit, Strong heart study

I.INTRODUCTION

Blood is a hydrating fluid, it is almost taught and learnt everywhere that blood is a transportation system of the body. But instead blood is an organ of our body itself. The volumetric ratio of blood to brain is (3:1) - (4:1), comparing that of blood to liver is (2:1)- (3:1) [21].

A. Blood Pressure

The main duty of heart is to pump blood to all the parts of the body. While this process is being done blood travels along the blood vessels and it pushes itself along the sides of the blood vessels. This pushing strength of the blood is called as Blood Pressure. Or it can be simply defined as the measure of force exerted by the blood on the blood vessels can be termed Blood Pressure.

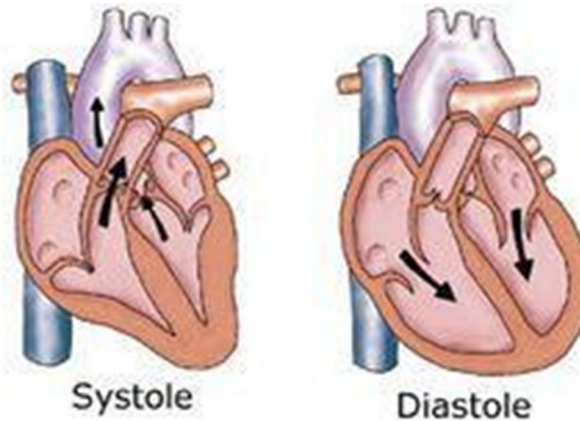
B. Blood Viscosity

A simple definition of blood viscosity is “the force which acts against the flow of blood” is called as blood viscosity. It is the friction force that comes into action due to the flow of blood in blood vessels. Its measure directly influences the functioning of heart, it is with how much intensity heart has to work to overcome that resistive force. The blood viscosity is reported in millipoise and its normal value in adults is found to be 40/100, and read as forty over hundred. And an interesting fact on blood viscosity is, it is approximately five times more than that of water[21].

By the definition of blood viscosity we can find that there is some relation between blood pressure and blood viscosity. Since it is necessary to know the participation of blood viscosity in the measurement of blood pressure, work in this paper gives a clear view of “Blood Viscosity And Its Influence On Blood Pressure”.

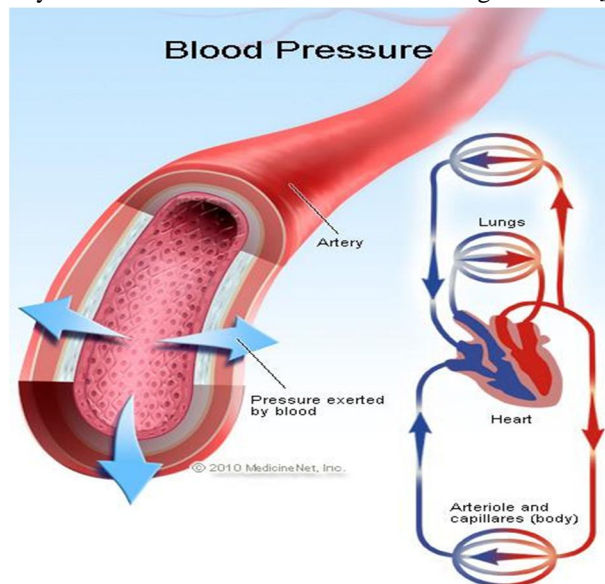
II.SOME BASIC DEFINATIONS

To get a grip on further concepts lets first concentrate on some basic terms. “Systolic blood pressure” and “Diastolic blood pressure”. Heart expands and contracts during its functioning. The contraction of heart to push blood through blood vessels is called “systole” and its relaxation is called as “diastole”. The pressure exerted by blood on the arteries during systole is called as systolic blood pressure. The normal systolic pressure is generally found to be 120 or less. In actual practice systolic blood pressure is said to be normal when it varies between 120-139. Pressure exerted by blood on the vessels during diastolic period of heart is called as the diastolic blood pressure and its value varies between 80-89. While taking the reading of blood pressure systolic blood pressure is the numerator and the diastolic blood pressure is always in the denominator. Hence blood pressure is noted as 120/80(normal blood pressure).



III. RELATION BETWEEN BLOOD PRESSURE AND BLOOD VISCOSITY

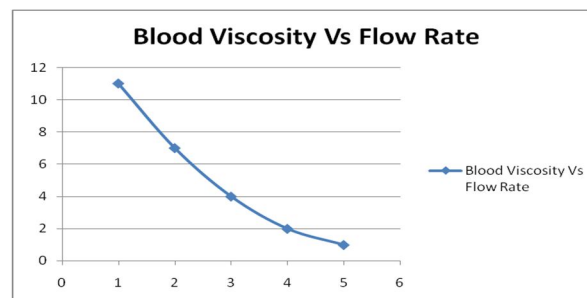
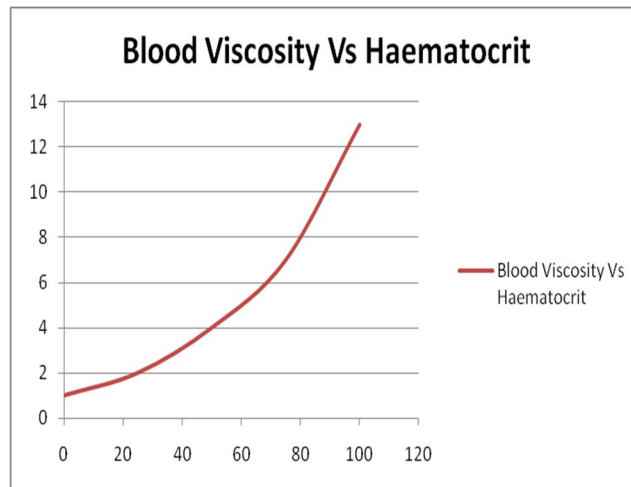
Blood pressure depends on blood viscosity. The relationship between blood pressure and blood viscosity is in such a way that, if the systolic blood pressure is maintained at a constant level and the blood viscosity is increased then the total peripheral resistance (TPR) will increase. This will reduce the blood flow. If blood viscosity decreases then the blood flow increases and TPR will necessarily decrease. Since systolic blood pressure depends on the arterial blood pressure, if the blood viscosity increases then arterial pressure increases which in turn leads to increase in systolic blood pressure. Hence due to higher viscosity the blood flow decreases and the work of heart to pump blood also increases. Hence due to change in viscosity of blood it directly becomes a major factor that affects blood pressure. At systole (higher shear rate) blood is thinner and at diastole (lower shear rate) blood is 2-5 times thicker. Hence the effect of blood viscosity also has its influence at the diastolic stage of heart.[1]



IV. BLOOD VISCOSITY VS HAEMATOCRIT:

Haematocrit is the volumetric ratio of red blood cells to that of blood. The concentration of erythrocytes influences blood viscosity and thus the blood pressure. The blood viscosity is approximately 3 times more than that of plasma and 5 times that of water at a haematocrit of 40-45% [12]. Blood viscosity exhibits a curvilinear relation with haematocrit and it increases sharply with increase in the value of haematocrit. The relation between red blood cells and blood viscosity reveals that increase in haematocrit leads to decrease in blood flow, this condition especially occurs at higher haematocrit levels. Even the rate of oxygen delivery to the tissues depends on the viscosity of blood. The arterial oxygen content is directly proportional to haematocrit. The graph between the rate of oxygen delivery and haematocrit shows a bell shaped curve. The rate of oxygen delivery to the tissues is slow at both high and low haematocrit levels. At low haematocrit levels arterial oxygen content is low and at high haematocrit levels blood viscosity is high. 40% about the normal haematocrit levels, is the optimum haematocrit for the maximum delivery of oxygen [22].

Fibrinogens and Globulins, the two plasma proteins whose elevation in concentration leads to the increase in the blood viscosity by two mechanisms. The plasma viscosity is elevated first. Fibrinogen and globulins have the capability of developing surfaces of red blood cells to form rouleaux. This occurs when the rate of flow of blood is slow and such a gathering of erythrocytes eventually lead path for the increase of viscosity of blood.



The above two graphs give the relation between blood viscosity and haematocrit, blood viscosity and blood flow rate.

A. Three Important Studies

According to the relationship between blood pressure and blood viscosity the following three major case studies were adopted. Blood pressure and blood viscosity among normotensive and hypertensive is differed as follows:

Systolic blood viscosity is 8 to 10% greater in hypertensive patients when compared to normotensive. Diastolic blood viscosity is 16 to 28% greater in hypertensive patients in contrast to normal person. Viscosity in Hypertensive person is remarkably greater even after analyzing 25 subjects which form a subgroup.

V. EDINBURG ARTERY STUDY:

“Edinburg Artery Study”, which was conducted in 1990’s was the largest blood viscosity study ever conducted. For this study, 1,592 middle aged people were taken into consideration for a mean of 5 years. This study revealed a new relation between heart problems and blood viscosity that, people who encountered heart attacks and strokes have high blood viscosity than those who did not. It disclosed that 20% of the individuals with high viscosity have become victims for 55% heart attacks and strokes during a span of 5 years. In this study the interesting point is that, these conclusions were solely based on measuring the systolic blood viscosity, hence the link between the cardiovascular disorders and blood viscosity is was stronger than between that of smoking and cardiovascular diseases.[3]

Indiscriminately 1592 adults were picked out to perform a survey, which involves an expression with single variable relating it to blood viscosity, for systolic blood pressure in males and diastolic blood pressure in both male and female. Blood viscosity levels after hematocrit corrections had remarkably associated to systolic and diastolic blood pressure. Hematocrit, plasma content, erythrocyte deformability and fibrinogen are the main causes for the link among blood pressure and blood viscosity. The continuing

study involves 331 males who were diagnosed recently having hypertension for along span of 12 years. Depending upon the diastolic blood viscosity patients are divided into:

1. High diastolic blood viscosity
2. Medium diastolic blood viscosity
3. Low diastolic blood viscosity

Higher diastolic blood viscosity patients are probably expected to have cardiovascular problems, this is because their diastolic blood viscosity is three times the lower diastolic blood viscosity. This study finally states that for a single variable analysis blood viscosity and hematocrit were the main reasons for cardiovascular diseases in hypertensive men whereas in multi variable analysis only blood viscosity has become the dominant cause. Hence diastolic blood viscosity is the vital reason for the cardiovascular problems in hypertensive men. Cell concentration, cell aggregation, cell deformability, plasma protein concentration are the constituents for measuring of flow resistance offered by bulk blood which is mentioned as blood viscosity.

Irregularities in blood viscosity have been compromised in number of cardiovascular diseases.

Attentiveness regarding the relationship between hypertension and blood viscosity was discovered by Poiseuille about the role of blood viscosity in explaining about vascular resistance.

According to the study performed blood viscosity is unconstrainedly related to diastolic blood pressure

But unrelated to systolic pressure, regarding this testing new relations of blood pressure with hypertension and other cardiovascular problems came into existence. Although most of the mechanisms were inexact. In epidemiological research *in vitro* blood viscosity is complicated and technically problematic. Relationship among blood viscosity (rheological components) and blood pressure have been infrequently discussed in widespread people. A population based survey on American Indians was Strong Heart Study, this survey preferred mainly obesity and diabetes patients which provides a scope to analyze cross sectional federation among the blood pressure and blood viscosity, which results in cardiovascular issues, without surprise of medicine. With charity the survey has been executed only by in the light of viscosity at a shear rate of 208 second. Approaching the shear stress in arterial and arteriolar circulation. In consideration with arterial hypertension sometimes the relationship between blood pressure and blood viscosity have been studied [13]. Relative Hyperviscosity is caused due to hypertension in most of the clinical patients but hyperviscosity is not due to blood pressure. Hemoconcentration is due to increase in blood viscosity which results in rise in blood pressure by filtration pressure. Present hypothesis says that hypertension is not directly associated with high blood viscosity, still stimulate environmental factors, involving obesity, physical inactivities and cigarette smoking. The present research used a regression equation saying that arterial hypertension was not linked with blood viscosity, which has considered total plasma proteins and hematocrit. In the strong heart study among the total population 81% normotensive individuals were having weak negative relationship was observed among blood viscosity and systolic pressure. Due to this reason we concentrated on the interconnection between blood viscosity and pulse pressure, which contemplates greater pulse pressure was separately linked with lower blood viscosity and hematocrit. Blood viscosity established liberated negative link with pulse pressure, encouraging in the vacation of hypertension in normal patients, as stroke volume increases pulse pressure increases positively. There are two possible reasons in differing the patients.

1. Negative pulse pressure and blood viscosity relationship in normal individuals can be counterbalanced by hypertensive adults.
2. Blood pressure, obesity, diabetes, pulse pressure is proportionally more affected by the pressure burden imposed on the arterial tree and the arterial stiffness, therefore causing cardiovascular system is more settled. Transparent varying on the link among arterial hypertension and rising blood viscosity. Likely without substantial modifications of renal hemodynamics and relatively mild hypertension explained the hypertension in the present study. An absolute positive relationship between hypertension and blood viscosity was observed in the present research among the people (not only hypertensive patients). Another main aspect is untreated hypertensive subjects, as mentioned in the previous clinical studies many participants received antihypertensive therapy.

Antihypertensive therapy can influence blood viscosity:

1. Inducing diuresis and causing hemoconcentration
2. Directly effecting red blood cell filterability.

to decrease both blood viscosity and blood pressure we have a treatment called antihypertensive.

THE STRONG HEART SURVEY:

Strong heart study is one of the longitudinal survey which focuses on the cardiovascular problems and disorders in American Indians.

which involves:

Arizona - 3 communities

Southwestern Oklahoma - 7 communities

South and north Dakota-3 communities

The examination was conducted in 1998-1999 and added hematocrit and plasma protein in phase 3. Which was not considered in phase 1 and phase 2. Among 3680 participants -1793 hypertensive and 1887 normal patients were examined .

In this participants 2491(67%) people are using medicines (cardioactive medication) angiotensin converting enzyme inhibitors, diuretics, ca-channels blockers, other antihypertensive drugs ,digoxin or aspirin . Among the left over population 513 people were suffering from coronary heart disease, congestive heart failure, valve disease and cerebrovascular disease . 676 people included in the obese and diabetic problems [5,6,7].

Obesity and central fat distribution have been given by “NATIONAL INSTITUTES OF HEALTH GUIDELINES”.

Diabetes was recognized by “AMERICAN DIABETES ASSOCIATION CRITERIA”.

Diagnosis of untreated hypertension was given as follows :

Blood pressure ≥ 140 mm Hg systolic and /or ≥ 90 mm Hg diastolic blood pressure was measured 3 times during the clinic visit , in a time of =10 minutes , by following the standard procedure used for the survey

VI. CHARECTERISTICS OF PARTICIPANTS:

In Arizona; diabetes, obesity, central fat distribution were found to be more prevalent when compared to that in North and North Dakota and in Oklahoma. When comparison made I the case of smoking it was more frequent in north and south Dakota than in Arizona and Oklahoma.

Obese were 324(48%), 233(35%) were overweight, 514(76%) have central fat distribution, among the participants . And these people were differentiated based on the values given by National Institutes Of Health. Among them diabetes a common health disorder was found among 288(43%) and 214 among them were women. Hypertension was spotted in 128(19%), among them 88 were women and 205 participants were smokes[13].

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