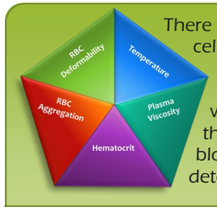
What determines blood viscosity?

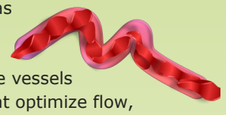


There are five primary determinants of blood viscosity: hematocrit, red blood cell flexibility, plasma viscosity, red blood cell aggregation and sedimentation, and body temperature. Other factors affecting blood viscosity do so by affecting one of these five primary determinants. For example, people with diabetes or impaired glucose tolerance have higher blood viscosity than those with normal glucose tolerance.[10-11] This is because fluctuating blood sugar decreases the flexibility of red blood cells, the second primary determinant of blood viscosity.

Hematocrit

Hematocrit has the biggest impact on blood viscosity. Hematocrit represents that percentage of whole blood that is made up of red blood cells: the higher the percentage of RBCs, the thicker the blood. Pre-menopausal women are at much lower risk for strokes and heart attacks than men. This can be attributed in great part to their lower hematocrit that results from a monthly loss of blood. This advantage is largely lost after menopause, when hematocrit rises.[12-13]

Red Blood Cell Flexibility

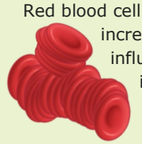


Red blood cell flexibility closely follows hematocrit in its importance as a factor contributing to blood viscosity. Also known as red blood cell deformability, this refers to the ability of red blood cells to change their shapes according to the dynamics of the blood vessels. In large vessels where blood is flowing faster, flexible red blood cells form shapes that optimize flow, decreasing the impact on and damage to blood vessel walls. In capillaries, flexible red blood cells bend and fold themselves into shapes that allow greatest perfusion of tissues. More rigid cells form shapes that are more likely to aggregate and form the beginnings of clots.[8,14-15]

Plasma Viscosity

Plasma viscosity is a lessor but still important contributor to whole blood viscosity. Plasma viscosity is greatly affected by hydration status.[16-17] It is also influenced by the concentration of high molecular-weight proteins, such as immune globulins and fibrinogen.

Red Blood Cell Aggregation



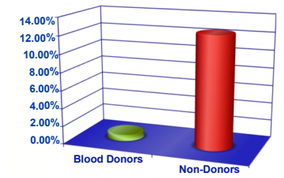
Red blood cell aggregation is the tendency of red cells to be sticky and clump together, increasing the risk of clot formation. RBC aggregation is complex and is influenced by both RBC flexibility and plasma viscosity. Inflammation also increases the stickiness of red blood cells and increases RBC aggregation.

Temperature

As with most fluids, blood is less viscous when it is warmer and more viscous when it is cooler. A 1°C rise in body temperature will result in an approximately 2% decrease in blood viscosity.[8] This is the equivalent to the difference between a low (but not uncommon) temperature of 96.8°F and a normal body temperature of 98.6°F.

Target treatments according to the 5 primary determinants of blood viscosity.

Blood donation improves viscosity



Men who do not donate blood have nearly 18 times the risk of heart attack as blood donors. Blood donation and therapeutic phlebotomy decrease hematocrit and increase the number of younger, more flexible red blood cells.[18-19]

What changes RBC flexibility?[18-33]

Improved by. . .	*Impaired by . . .*
• Fish oil/Omega 3 FAs	• Elevated blood glucose
• Phosphatidyl choline	• Fluctuating osmolality
• Vitamin E	• Oxidative stress
• Acetyl-L-Carnitine	• Environmental toxins
• Ginkgo	• Excessive saturated fats
• Astaxanthin	
• S-Adnenosyl-L-methionine	
• Iron (in patients with iron-deficiency anemia)	
• Blood donation	
• Therapeutic phlebotomy	
• Detoxifiacation	

Hydration improves plasma viscosity

Drink 1/2 body weight in ounces, daily.[16]

Example: Weight = 140 lbs.
Drink = 70 oz

Reduced, alkalinized water may rehydrate more effectively than other waters.[17] Additional fluids and replacement of electrolytes may be prudent in conditions of extreme heat and/or prolonged vigorous exercise.

Supplements may decrease RBC aggregation [24,34-40]

- Nattokinase
- Lumbrokinase
- Serrapeptase
- Phosphatidyl choline

Optimize body temperature

- Improve thyroid function
- Exercise
- Constitutional hydrotherapy
- Saunas

Numbered references are available on the Meridian Valley Lab website at MeridianValleyLab.com

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Meridian Valley LAB

Understanding Your Complete Blood Viscosity Panel

Leader in preventive medicine since 1976

The Importance of Blood Viscosity

Whole Blood Viscosity is an important hemodynamic biomarker which has a strong predictive value for heart attack, stroke, cognitive decline, and complications of diabetes such as retinopathy, ulcerations, and the need for dialysis.[1-7] *It is correlated with all known risk factors for cardiovascular disease*[8] *and may be more clinically useful than traditional measures in assessing the likelihood of a cardiovascular event.*

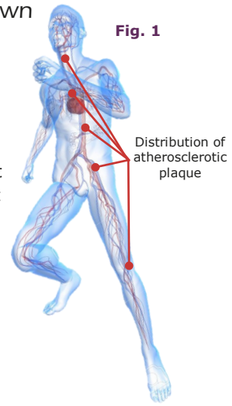


Fig. 1

Much is made of cholesterol as a risk factor in the development of atherosclerosis. While cholesterol does play a role in plaque formation, that role is as a biological bandage, covering and protecting an injury to the arterial wall. In this way the body buys short-term survival but at the cost of a longer-term loss of function. It is the initial injury to the blood vessel wall that triggers plaque formation, and that injury is a function of blood viscosity and the dynamics of blood flow. This is seen in the distribution of plaque in the human cardiovascular system.

Atherosclerotic plaques are not found uniformly throughout the body, but are localized in the large arteries closest to the heart and leading to the brain. Plaque is also found in large arteries off of the descending aorta and in the leg, where the action of gravity increases shear force.[8-9] (Fig.1)

How does high viscosity initiate plaque formation?

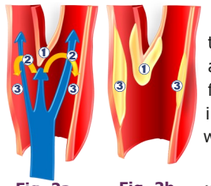


Fig. 2a **Fig. 2b**

Viscous blood is abrasive and damages the delicate lining of blood vessels, initiating the atherosclerotic process. This is illustrated in Figure 2a. Damage to the intima occurs at the bifurcation point of an artery ① where velocity and force are the highest. Turbulent flow ② also causes damage at the lateral walls proximal to the bifurcation. ③ Figure 2b illustrates the locations where arterial plaques are typically found — exactly at the locations where viscous blood has the greatest impact.

Blood flowing fast (such as at systole) is less viscous than slower-flowing blood (diastole). (Fig. 3) Blood viscosity at diastole is typically 2-5 times greater than blood at systole, and sometimes more. (Fig. 4) Thus, blood viscosity is dynamic parameter, constantly shifting from more to less viscous with every heartbeat. Blood viscosity assessment is accordingly most clinically relevant when it is able to measure blood viscosity at both high shear (systolic) and low shear (diastolic) velocities. With state-of-the-art scanning capillary viscometers, Meridian Valley Lab's Complete Blood Viscosity Profile is the only commercially available blood viscosity test to measure an entire spectrum of shear rates and provide meaningful values for both high shear and low shear blood viscosity.

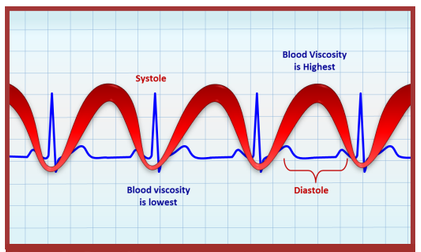


Figure 3: Blood Viscosity through the cardiac cycle. When the heart contracts (systole), blood flows faster and is less viscous. When the heart relaxes (diastole) blood flow slows. Slower-moving blood is more viscous.

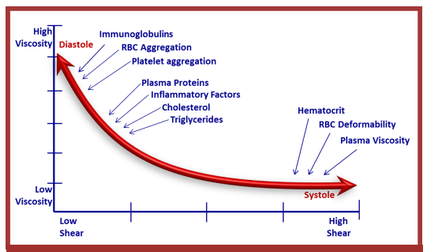
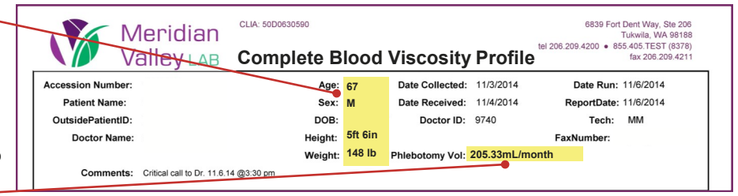


Figure 4: Factors Affecting Blood Viscosity. Blood viscosity is correlated with all known risk factors for cardiovascular disease.[8] These factors impact blood viscosity at a different places along the curve.

The Complete Blood Viscosity Profile

Patient Information:
This section includes important information (age, gender, height, weight) that is used to calculate phlebotomy volume for patients for whom therapeutic phlebotomy is indicated. When this information has been provided, this section also includes recommended monthly phlebotomy volume to improve blood viscosity and decrease risk of cardiovascular events.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Complete Blood Viscosity Profile

Accession Number:		Age:	67	Date Collected: 11/3/2014	Date Run: 11/6/2014
Patient Name:		Sex:	M	Date Received: 11/4/2014	ReportDate: 11/6/2014
OutsidePatientID:		DOB:		Doctor ID: 9740	Tech: MM
Doctor Name:		Height:	5ft 6in		FaxNumber:
		Weight:	148 lb	Phlebotomy Vol: 205.33mL/month	

Comments: Critical call to Dr. 11.6.14 @3:30 pm

Blood Viscosity Section:
This section reports systolic and diastolic blood viscosity. Optimal systolic viscosity is <42. Optimal diastolic viscosity is <111.


Blood Viscosity Test Results

Test	Out of range	Results	Reference Range	Units
Systolic	High	47.3	30 - 44	mP
Diastolic	High	159	74 - 126	mP

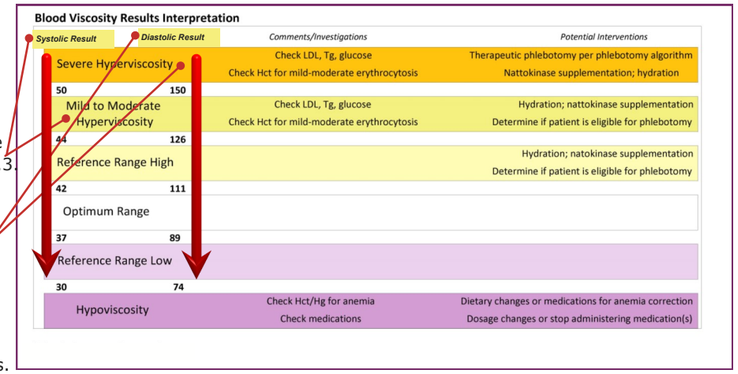
CBC Section:
A standard Complete Blood Count, this section helps us to evaluate possible etiologies of increased viscosity, such as a high or high-normal hematocrit. Optimal hematocrit for men is around 42; for women optimal is around 38.

Bun/Creatinine:
A BUN/Creatinine ratio of >15 may suggest under-hydration. Under-hydration impacts plasma viscosity, one component of whole-blood viscosity.


CBC Test Results — Quest

Test	Out of range	Results	Reference Range	Units
White Blood Cells		4.8	3.8 - 10.8	K/µL
Red Blood Cells		5.33	4.2 - 5.8	M/µL
Hemoglobin		16.1	13.2 - 17.1	g/dl
Hematocrit		47.3	38.5 - 50	%
MCV		88.7	80 - 100	fL
MCH		30.2	27 - 33	pg
MCHC		34	32 - 36	g/dl
RDW		13.5	11 - 15	%
Platelets		302	140 - 400	K/µL
BUN		16	7 - 25	mg/d
Creatinine		1.05	0.7 - 1.25	mg/d

Interpretation:
The interpretive section provides a general interpretation of where the blood viscosity results fall with respect to optimal blood viscosity. The scales are read vertically. For example, the patient on this sample report has a systolic viscosity of 47.3. Reading down the Systolic Result column, this value falls between 50 and 44 in the Mild to Moderate Hyperviscosity range. His diastolic viscosity of 159 falls above 150 in the Diastolic Result column, placing him in the Severe Hyperviscosity range. This section also includes some general therapeutic guidelines.


Blood Viscosity Results Interpretation

Systolic Result	Diastolic Result	Comments/Investigations	Potential Interventions
Severe Hyperviscosity	50 150	Check LDL, Tg, glucose Check Hct for mild-moderate erythrocytosis	Therapeutic phlebotomy per phlebotomy algorithm Nattokinase supplementation; hydration
Mild to Moderate Hyperviscosity	44 126	Check LDL, Tg, glucose Check Hct for mild-moderate erythrocytosis	Hydration; nattokinase supplementation Determine if patient is eligible for phlebotomy
Reference Range High	42 111		Hydration; nattokinase supplementation Determine if patient is eligible for phlebotomy
Optimum Range	37 89		
Reference Range Low	30 74		
Hypoviscosity		Check Hct/Hg for anemia Check medications	Dietary changes or medications for anemia correction Dosage changes or stop administering medication(s)

Therapeutic Oral Hydration Guidelines

If systolic viscosity > 41 or diastolic viscosity > 110:

- Hydrate one-half (1/2) of the patient's body weight in ounces daily.
  Example: 100 oz of water daily for a 200 lb patient

Consider increasing hydration volume and adding electrolytes if:

- Ambient temperature is high or humidity very low
- Patient loses fluid through sweating (saunas or exercise)

Nattokinase Guidelines

If systolic viscosity > 44 or diastolic viscosity > 126 consider:

- 50 mg of nattokinase (1,000 fibrinolytic degradation units) three times daily with food.
- For patients also diagnosed with atrial fibrillation or having an artificial heart valve, consider 50 mg nattokinase four times a day.
- Oral hydration, per guidelines
- Nattokinase is contraindicated for patients with hemophilia.

Phlebotomy Guidelines

- Complete Blood Viscosity Profile with height, weight, and gender are required to determine recommended phlebotomy volume.
- For 100-250 cc of monthly blood volume removal, phlebotomy without IV pre-hydration is generally acceptable.
- For >250 cc of blood volume removal, IV hydration using normal saline is recommended. Use the same volume of saline as blood being removed: one-half before and one-half after phlebotomy.
- Re-test viscosity after one month, prior to the next phlebotomy.
- Therapeutic phlebotomy greater than 500 cc per month is not recommended for any patient.

These guidelines are not a substitute for the clinical judgment of a qualified medical practitioner.