Influence of Magnetic Field on Blood Viscosity

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ABSTRACT
The effect of magnetic field on blood samples has been studied. Blood was extracted from donors most of them are men with polycythemia (hyper-viscosity) disease. In this study (10 ml) blood samples anti-clotting tubes were put under the influence of a steady magnetic field (MRI) (1.5 Tesla) for different exposure time. It was clearly observed in the present study that the viscosity of blood samples had been decreased with increasing the exposure time to magnetic fields. This decrease in viscosity was great for samples exposed for (1) minute and (15) minutes.

KEYWORDS: MRI, Blood viscosity, Magnetic field

INTRODUCTION

Since 1980, the effects of applying a magnetic field to liquid water have been intensively studied. It has been shown that the water vaporization rate, an essential process for all biological processes, is significantly affected by the application of a static magnetic field in both air and oxygen environments[1].

Studies have found that various aspects of the liquid water structure, including the size of the water cluster change when exposed to a magnetic field.[2,3]

The viscosity of a fluid is a measure of its resistance to gradual deformation by shear stress or tensile stress. For liquids, it corresponds to the informal concept of thickness [4], also viscosity known as kinematic viscosity, absolute viscosity or simple viscosity and defined mathematically as the ratio of the shear stress to the velocity gradient in a fluid [5], due to Newton’s equation for fluids, which similar to Newton’s second law of motion[6] as follows:

$$\eta = \frac{F}{\Delta \frac{\Delta \rho_u}{A \Delta x}}$$

$$\eta = \text{the fluid Viscosity.}$$
$$\Delta \rho_u = \text{The viscosity gradient in a fluid.}$$
$$F: \text{force.}$$
$$A: \text{area.}$$
$$f: \text{friction force.}$$

Blood viscosity is a measure of resistance to flowing speed of blood; it can also be described as the thickness and stickiness of blood [7]. It is a direct measure of the ability of blood to flow through the vessels; also it is a key screening test that measures how much friction the blood causes against the vessels, how hard the
heart has to work to pump blood, and how much oxygen is delivered to organs and tissues. Importantly, high blood viscosity is easily modifiable by safe lifestyle-based interventions. The viscosity of blood is approximately (1.8) times the viscosity of water at (37°C) and is related to the protein composition of the plasma. Also, viscosity changes as temperature and blood flow changes [viscosity increases (2%) for each degree Celsius (°C)] increased. Low blood flow results are an increase viscosity due to the cell-to-cell and protein adhesive interactions that can cause erythrocytes to adhere to one another. Blood density is (1.060Kg/m³) at (37°C) [8].

MATERIALS AND METHOD

1) A(110) donors, mostly males, we prepared at work site (in order to avoid differences in time and temperature) donors their age between 24 to 58 years.
2) 18 to 20 ml of blood was extracted from a vein in the arm of donors and the samples were placed in a laboratory tube containing (anti-coagulant) to prevent clotting of the blood.

The samples which had been extracted from donors were divided (each donor) into two parts by (8ml each sample). The first part is control sample. The second part of the samples (for each donor) was exposed to a magnetic field, from Magnetic Resonance Imaging (MRI) ((in Al-Amal Hospital of cancers in Baghdad) produce the German company Siemens in 2011), which gives a fixed magnetic field by 1.5 T.
3) Blood which had been extracted exhibited to magnetic field (1,3,5,7,9,1113,15,17,19,21) minutes.
4) The density of blood samples (blood controls and exposed to a magnetic field) was calculated (in laboratory temperature (25°C)), by taking a tube (5 ml volume).
5) The weight of tubes has been measured with and without blood using a sensitive electronic scale.

The density of blood viscosity obtained by using the following equations:

\[ \eta_b = W_{b+t} - W_t \]  

Where:

- \( W_b \): The net weight of the blood.
- \( W_{b+t} \): The weight of the blood with the tube.
- \( W_t \): The net weight of the tube.

\[ \eta = \frac{\eta_1 \cdot t_1}{\eta_2 \cdot t_2} \]

Where

- \( \eta_1 \): Blood viscosity.
- \( \eta_2 \): Distilled water viscosity
- \( d_1 \): Blood density.
- \( d_2 \): Distilled water density.
- \( t_1 \): Flowing time of blood
- \( t_2 \): Flowing time of distilled water.

RESULTS AND DISCUSSION

The effect of the magnetic field was studied on kinematic blood viscosity of fresh blood for 110 donors, this effect studied by changing the exposure time of magnetic field influence. The results treated statistically, and arranged in the table (1) which shows in variation of blood viscosity with increasing of the time effect of magnetic field with compare to their value in control samples (samples before the influence of magnetic field).

We can discuss the decrease of blood viscosity with the exposure time due influence of magnetic field as follows:
1- The blood viscosity was reduced by applying a high magnetic field of one tesla or above parallel to the blood flow direction. One magnetic field of 1.5 T lasting ≈1 min. Can reduce the blood viscosity by (20% to 30%).
2- Red blood cells (RBC) travel in clusters typical of fatigue, stress or health problems present in most people in varying degrees, but by supplementary of the magnetic field of influences the iron in the blood cells, spinouts the cells around and points them in one direction as in fig (1)[12,22].that means that the (RBCs), it becomes more free in movement, which increases the speed of the blood flow in the Viscometer tube.
3- The strong magnetic field aggregates red blood cells along the field direction to form short chains[9].
4- Polarization of the red blood cells allows the cells repel each other and frees up much more surface area to carry oxygen and release more carbon dioxide (22,23), this Why red blood cells become lighter because the molecular weight of the (CO\(_2\)) is the largest of oxygen(O\(_2\)).
Table 1: effect of magnetic field on blood viscosity in different exposure time.

<table>
<thead>
<tr>
<th>Viscosity(cSt*) of control Samples</th>
<th>Time of exposure (min)</th>
<th>Viscosity(cSt) after magnetic field</th>
<th>P value from baseline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean±SD</td>
<td>Range</td>
<td>Mean±SD</td>
<td>Range</td>
</tr>
<tr>
<td>6.834±1.230</td>
<td>(4.786-8.454)</td>
<td>5.220±0.947</td>
<td>(3.675-6.547)</td>
</tr>
<tr>
<td>6.738±0.922</td>
<td>(5.650-8.160)</td>
<td>5.804±0.966</td>
<td>(4.654-7.405)</td>
</tr>
<tr>
<td>6.615±1.346</td>
<td>(4.766-8.528)</td>
<td>5.546±1.334</td>
<td>(3.890-7.877)</td>
</tr>
<tr>
<td>7.012±1.780</td>
<td>(6.003-8.564)</td>
<td>5.813±0.843</td>
<td>(4.443-7.098)</td>
</tr>
<tr>
<td>6.679±0.881</td>
<td>(5.423-7.873)</td>
<td>5.464±0.933</td>
<td>(4.329-6.547)</td>
</tr>
<tr>
<td>6.949±1.279</td>
<td>(5.110-8.788)</td>
<td>5.583±1.265</td>
<td>(4.110-7.324)</td>
</tr>
<tr>
<td>6.824±1.148</td>
<td>(5.679-8.943)</td>
<td>5.415±1.026</td>
<td>(4.032-7.057)</td>
</tr>
<tr>
<td>7.410±0.991</td>
<td>(5.432-8.766)</td>
<td>4.746±0.579</td>
<td>(3.995-5.633)</td>
</tr>
<tr>
<td>7.017±1.213</td>
<td>(5.254-8.909)</td>
<td>5.559±1.095</td>
<td>(4.134-7.323)</td>
</tr>
<tr>
<td>6.841±0.983</td>
<td>(5.032-5.543)</td>
<td>5.492±0.861</td>
<td>(4.088-7.229)</td>
</tr>
<tr>
<td>6.731±0.859</td>
<td>(5.785-8.654)</td>
<td>5.462±0.829</td>
<td>(4.769-7.547)</td>
</tr>
</tbody>
</table>

*Significant difference between two dependent means using Paired-t-test at 0.05 levels.

To explain the effect of magnetic field, the average of control samples for all (110) donors has been taken, which was (6.88cSt) this value considered as (0) Min, as shown in Fig (1):

The percentage of reducing with exposure time to magnetic field appeared in Fig(2):

Conclusion:
1- Exposing fresh whole blood to 1 minute of the magnetic field 1.5 T, using MRI decreasing blood viscosity≈23%.
2- Exposing fresh whole blood to 15 minutes a magnetic field of 1.5 T lead to decreasing viscosity $\approx 35\%$, this is considered very useful decreasing viscosity value can be depending in treatment to people with high viscosity.
3- Increasing time of exposure to magnetic field up 15 min till 20 min, increasing viscosity to normal levels, so is not harmful in Magnetic resonance imaging RMI.

REFERENCES