Blood is thicker than water—and blood plasma is, too (w/ Video)

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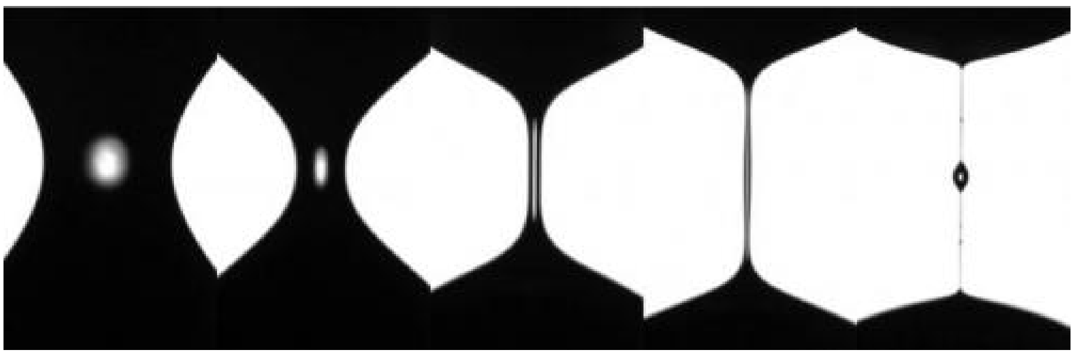
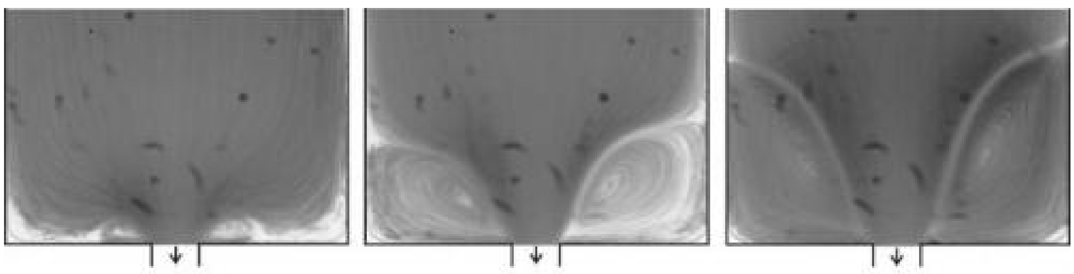


Blood plasma is placed between two plates and the plates then drawn apart. High-speed cameras fitted with high-resolution microscope lenses capture the formation of threads and drops, demonstrating that blood plasma exhibits both viscous and elastic behavior when deformed and that it does not behave like water. Credit: Christof Schäfer, *Phys. Rev. Lett.* 110, 2013, 078305. Copyright (2013) by the American Physical Society

(Medical Xpress)—The results are significant because they can help to improve our understanding of medical conditions, such as thrombosis, aneurysms and arteriosclerosis. The research team is publishing its results in *Physical Review Letters*.

Blood flows differently than water. Anyone who has ever cut themselves knows that blood flows viscously and rather erratically. The similarity between blood and ketchup is something not only filmmakers are aware of. Experts refer to these materials as "non-Newtonian fluids," of which ketchup and blood are prime examples. These fluids have flow properties that change depending on conditions, with some becoming more viscous, while others become less viscous. Blood (like ketchup) is a "shear thinning fluid" that becomes less viscous with increasing pressure and it is this that allows blood to flow into the narrowest of capillaries. The flow properties of water are, in contrast, essentially constant.



Plasma influences the formation of vortices in blood. In one experiment, the researchers let blood plasma flow through a microfluidic channel such as is found in a constricted blood vessel. They observed vortices at the end of the channel, but also -- as shown in these images -- at the entrance to the channel. These vortices are created because of the viscoelastic properties of blood plasma. Credit: Mathias Brust, *Phys. Rev. Lett.* 110, 2013, 078305. Copyright (2013) by the American Physical Society

Up until now it has been assumed that the special flow characteristics exhibited by blood were mainly due to the presence of the red blood cells, which account for about 45 percent of the blood's volume. Blood plasma was generally regarded simply as a spectator that played no active role. For decades, researchers have assumed that blood plasma flows like water. After all, plasma, the liquid in which the blood cells are suspended, consists to 92 percent of water. But results from researchers at Saarland University and at the University of Pennsylvania have now shown that plasma is a very special fluid that plays a crucial part in determining how blood flows. The results demonstrate that blood plasma is itself a non-Newtonian fluid.

According to the study's findings, the complex flow behavior of blood plasma could play a crucial role with respect to vascular wall deposits, aneurysms or blood clots. The results from this research may well help to improve computer simulations of this kind of pathological process.

The research team around experimental physicist Christian Wagner and engineer Paulo E. Arratia have studied the flow dynamics of blood experimentally. The work at Saarland University involved experiments in which the blood plasma was allowed to form drops inside a specially built apparatus equipped with high-speed cameras fitted with high-resolution microscope lenses to analyze drop formation. "Our experiments showed that the blood plasma forms threads, that is, it exhibits an extensional viscosity, which is something we do not observe in water," explained Professor Wagner. The plasma shows "viscoelastic" properties, which means that it exhibits both viscous and elastic behavior when deformed, forming threads that are typical of non-Newtonian fluids.

The studies by Professor Arratia and his team at the University of Pennsylvania involved a microfluidic approach in which they developed a model of a microvascular system in order to study the flow properties of blood plasma. Their measurements showed that blood plasma exhibits a flow behavior different to that of water and that plasma can demonstrate a substantially higher flow resistance. "An important part of our study was developing microfluidic instruments sensitive enough to pick up the small differences in viscosity that are the signature of non-Newtonian fluids," explained Professor Arratia.

Experiments performed by Professor Wagner's team in Saarbrücken also showed that blood plasma influences the creation of vortices in flowing blood. These vortices may facilitate the formation of deposits on blood vessel walls which could influence blood clot formation. In one of their experiments, the research team let plasma flow through a narrow channel of the kind found in stenotic (constricted) arteries or in a stent (a medical implant inserted into constricted blood vessels). The vortical structures were detected at the end, but also at the entrance, of the narrow channel and their formation is a direct result of the viscoelastic flow properties of blood plasma.

More information: *Phys. Rev. Lett.*, 110, 078305 (2013) DOI: 10.1103/PhysRevLett.110.078305

Provided by Saarland University