Healthy red blood cells flow in an ordered pattern unlike their diseased counterparts

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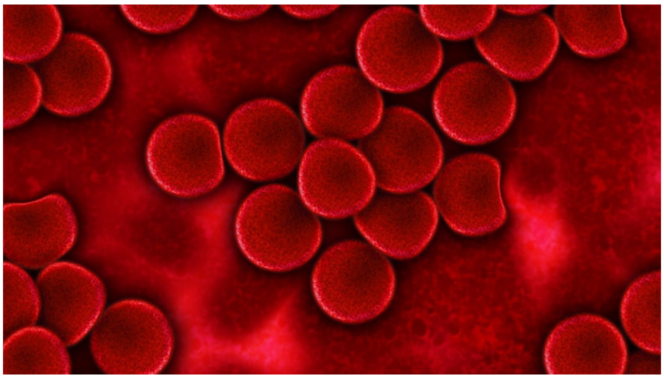

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An interdisciplinary, international team of researchers including Northwestern Engineering professor Petia Vlahovska has discovered that healthy red blood cells assemble into a two-dimensional crystal pattern whereas pathological red blood cells succumb to disorder.

The findings ignite the possibility of a novel diagnostics tool to detect blood pathologies in diseases such as sickle cell anemia, a disorder the World Health Organization has long identified as a prominent global health issue.

"In diseases such as sickle cell anemia, red blood cells are hardened and do not form 'crystals,' so the ordering can distinguish between healthy and diseased red blood cells and lead to a diagnostics tool to detect cardiovascular pathologies," said Vlahovska, an associate professor of engineering sciences and applied mathematics at Northwestern's McCormick School of Engineering and Applied Science.

Titled "Blood Crystal: Emergent Order of Red Blood Cells Under Wall-Confined Shear Flow," the study appeared in *Physical Review Letters* on June 28. Led by Chaouqi Misbah of Universite Grenoble Alpes and CNRS in France, the paper's co-authors included researchers from France, Germany, and the Netherlands in addition to Vlahovska, who has been collaborating with Misbah since 2007.

Through experiments and simulations, the researchers examined the common assumption of disordered blood flow. The six-member team found that a healthy red blood cell is rather soft and flexible, properties that contribute to the emergence of order under shear flow. When red blood cells are hardened in diseases such as sickle cell anemia, however, the that order is suppressed.

"Red blood cells have to constantly rearrange while blood is flowing through the body's network of blood vessels, and we discovered a new arrangement of the red blood cells' regular pattern in which they are lined in a chain-like formation," Vlahovska said.

Understanding red blood cell assemblies under flow is essential to deciphering many blood and cardiovascular pathologies, the main cause of mortality in the world. The research team's findings unlock a potential method to identify healthy and diseased red blood cells, which could be useful for diagnosis as well as therapeutic development.

"And that could impact millions of people around the globe," Vlahovska said.

In addition to advancing knowledge about blood flow, Vlahovska said the research team's work also contributes to the broader research area of self-organization in out-of-equilibrium, active systems.

"Living systems exist out of equilibrium and life is order that emerges from the 'equilibrium chaos,'" she explained. "One of the big challenges is to understand – so that eventually we can mimic – how individual units such as cells organize into structures such as tissues. The phenomenon we have discovered is not limited to red blood cells, but actually quite universal and one that can be realized in other synthetic systems.

More information: Zaiyi Shen et al. Blood Crystal: Emergent Order of Red Blood Cells Under Wall-Confined Shear Flow, *Physical Review Letters* (2018). DOI: 10.1103/PhysRevLett.120.268102

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