Researchers developing new blood spatter models to better reconstruct crime scenes

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UIC Professor Alexander Yarin. Credit: UIC College of Engineering

Blood spatter can provide a lot of informanulltion to an investigator at a crime scene. Unfortunately, current methods do not tell the whole story.

UIC Distinguished Professor Alexander Yarin and his colleagues have shown that investigators can gather more accurate information. Their blood spatter research has the potential to change crime scene investigations in the same way DNA changed other police investigations.

Yarin and his associates made a splash in the science and law enforcement communities with their research on blood spatter with their papers, *Prediction of Blood Backspatter from a Gunshot in Bloodstain Pattern Analysis*, which was published in the journal *Physical Review Fluids* in 2016, *High-Speed Video Analysis of Forward and Backward Spattered Blood Droplets* published in *Forensic Science International* in 2017, and *Hydrodynamics of back spatter by blunt bullet gunshot with a link to bloodstain pattern analysis*, published in *Physical Review Fluids* in 2017.

Back spatter is the blood that comes back toward the gun when it's shot at close range. A blood-spatter pattern is a collection of bloodstains produced by drops of blood that have traveled through the air from a source location to a target surface.

The research led them to develop a theoretical model for predicting and interpreting blood spatter patterns resulting from a gunshot wound.

The process generating a backward spatter is linked to the instability of blood accelerated toward the surrounding air allowing one to predict the initial distribution of drop sizes and velocities. Gravity and air drag are key factors as the drops move through the air. Also, droplet-to-droplet aerodynamic interactions are quite significant. Based on this information, which hasn't been considered in the past, a numerical solution was obtained. With this solution, the researchers can predict the disintegration process, the trajectories of the back spatter drops of blood from the wound to the ground, walls, or any other surface, the impact angle, as well as the distribution and location of blood stains and their

shapes and sizes.

Moving Research Forward

Now, Yarin and his team are researching forward blood spatter, which is blood that travels in the same direction as the bullet, which was recently published in *Physical Review Fluids* under the title Theoretical and Experimental Investigation of Forward Spatter of Blood from a Gunshot.

"We wrote the first proposal about back spatter. Then, the police told me that the forward spatter is also important because in many cases, they don't find the bullet," said Yarin.

"Mathematically, backward and forward spatter are very different," said Patrick Comiskey, an Arlington Heights resident working on his Ph.D. under Yarin's direction in the Multiscale Mechanics and Nanotechnology Laboratory at UIC. "What we've been able to do is predict the location – with the mathematical model we created. The intent is to better analyze crime scenes and to look at a more accurate way of recreating crime scenes."

Starting at the blood stain, investigators place metal rods on an estimated impact angle and consider the straight line as the trajectory and the intersection of the straight lines as the origin of the blood spatter.

"This method disregards the gravity effect on the droplet trajectory," said Yarin. "Essentially, they assume it went in a straight line, and disregard that the trajectory was actually curved. So the origin can be significantly different by half a meter or more."

"They judge the impact angle based on the ellipticity of the stain. However, math immediately shows that they can't distinguish between 75 and 90 degrees," he added. "Any angle above 75 degrees that they

would estimate is absolutely inaccurate. I believe they might be inaccurate at lower angles too."

Along with gravity, the researchers are looking at additional effects that are not being taken into account by investigators. There is an effect of the aerodynamic drag, which also spends droplet's initial kinetic energy.

"It is quite clear that aerodynamic drag is important," said Yarin. "If you don't account for the drag, the droplet flies too far. If you do account for the drag acting on a single droplet it flies insufficiently far. So it appears there is an important 'collective effect.' Similar to that of birds flying in the V-formation"

The collective effect can be observed when blood spatter is moving in a cloud, the front droplets take the entire drag and the trailing ones are moving much easier. Droplets upfront decelerate, and the others come forward. They don't fly very far, but also not very close to the origin.

According to Yarin, there are a number of interesting effects that have to be accounted for and predicted to allow police to have much more scientific methods of analysis of the blood pattern. And his team are already exploring the additional processes they want to address, which include forward and back spatter.

One issue they are researching is related to the effect of muzzle gasses. When a gun is fired, there is a shockwave and a gas flow following the shockwave which can deflect the blood droplets, especially at short range.

Apart from gun shots, the researchers are analyzing blood stains from beatings, which is different from a shooting as it spreads out in a fan-like jet in all directions, or as a single curved jet, similar to those of the Navy Pier fountains. They also are considering the surface where a droplet

lands and how it impacts the blood spreading. There are multiple interesting fluid mechanical questions related to crime scenes, and Yarin and his team are trying to answer them.

"There are many problematic practices in this field, and investigators and fluid mechanicists believe that a deeper understanding of the physical processes would be important," said Yarin. "Investigators need to have a scientific fundamental foundation of what they do and they want it. We are trying to be helpful."

The funding for the research is made possible by a $591,895 grant for two years from the U.S. Department of Justice through a subcontract from Iowa State University.

More information: P. M. Comiskey et al. Theoretical and experimental investigation of forward spatter of blood from a gunshot, *Physical Review Fluids* (2018). DOI: 10.1103/PhysRevFluids.3.063901

Learn more about Yarin's research at Multiscale Mechanics and Nanotechnology Laboratory.

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