Filed Under: Chemical Reactions, Forensic Chemistry, Forensic Technology, Forensics, Motions and Forces

Point Blank: The Impact of Guns on Blood Spatter

by Timothy Erick | May 2021

In the television series *Dexter*, the titular character works as a forensic technician for the Miami police department. He specializes in bloodstain pattern analysis (BPA), the reconstruction of the sequence of events of a violent crime based on the bloodstains left behind at the scene. Of course, his ability to interpret a murder scene is bolstered by his secret identity as a serial killer.

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Bloodstain pattern analysis, the reconstruction of the sequence of events of a violent crime based on the bloodstains left behind at the scene, is used by forensic scientists to help fill in details. Studying these blood spatter patterns can provide vital information about the location and position of the shooter and the victim.

In real life, BPA is used by forensic scientists to help fill in details about violent crimes. In the case of a gunshot wound, the impact of the bullet causes blood to project toward the shooter (back spatter), and, if the bullet travels completely through the body, onto surfaces behind the victim (forward spatter). Studying these blood spatter patterns can provide vital information about the location and position of the shooter and the victim.

The science behind BPA continues to evolve as we learn more about the physical forces that influence blood spatter. In addition to gravity and air resistance, blood droplets are also affected by the gas that exits the barrel of a gun after a bullet. Recently, a group of mechanical engineers conducted a series of theoretical analyses and supporting experiments to investigate the role of gun propellant gas on the size, shape, and flight patterns of blood droplets. Their methods and findings were published in two papers in the journal Physics of Fluids, with James B. Michael and Alexander L. Yarin as the corresponding authors.

Bloody Business

Any sort of violent altercation – whether it is a fist fight, a knife fight, or a gunfight – has the potential to result in blood loss from one or more participants. Each of these types of trauma causes blood to splash onto the surrounding surfaces in a specific manner. Gunshot wounds cause blood to spray from the body in small droplets. When one person shoots another, forensic scientists analyze the distribution of these blood droplets at the scene to try to figure out where the shooter and victim were positioned. For instance, the size and distribution of blood droplets on a suspected shooter's clothing can help determine whether they shot the victim in cold blood or self-defense, or indeed if they shot the victim at all.

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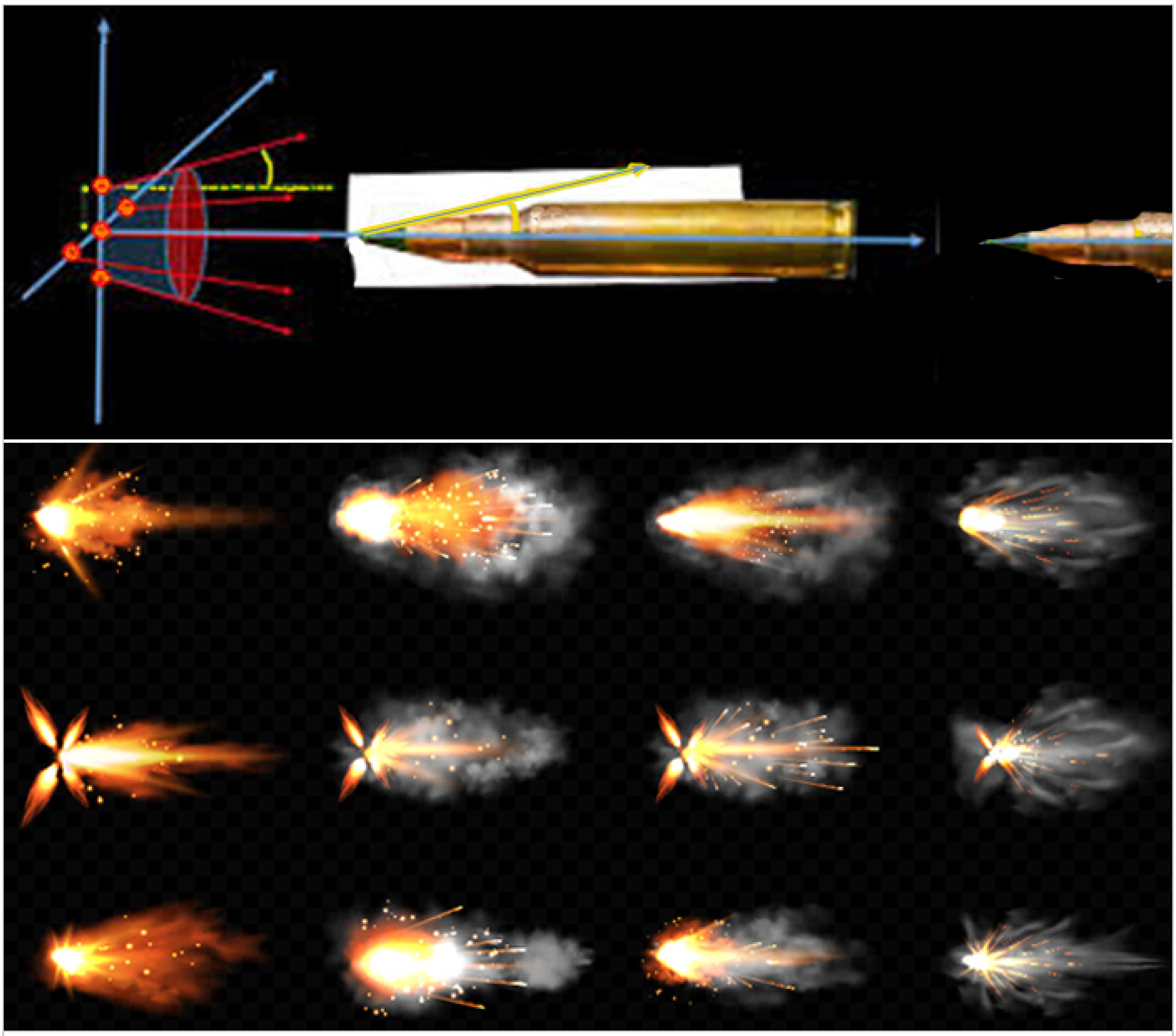
But, as is often the case in science, advances can have the result of exposing earlier shortcomings. For instance, early BPA methods assumed that blood droplets traveled in a straight path from the victim to the surrounding surfaces. However, this assumption neglected the influence of gravity and air resistance, both of which cause blood droplets to fall toward the ground after exiting the body. Thus, these early analyses often overestimated the height of the point of impact, which would skew any resulting conclusions about the position of the shooter and victim.

In recent years, further research into the physics of blood spatter has revealed additional shortcomings in existing BPA methods. As it turns out, firearm propellant gas exerts a significant influence on blood back spatter.

Anatomy of a Bullet

In modern firearms, each individual piece of ammunition is called a cartridge. Each cartridge contains three main components: the bullet, which is the solid projectile that sits at the front; the propellant (gunpowder), which sits behind the bullet; and a primer that sits at the base, behind the propellant. These components are held together in a metal case called a cartridge case. When the trigger of the gun is pulled, the hammer strikes the primer, which creates a chemical reaction that ignites the propellant. This in turn sets off a larger chemical reaction that produces a rapid expansion of gas, which propels the bullet out of the barrel of the gun toward the target. The propellant gas also exits the barrel shortly after the bullet.



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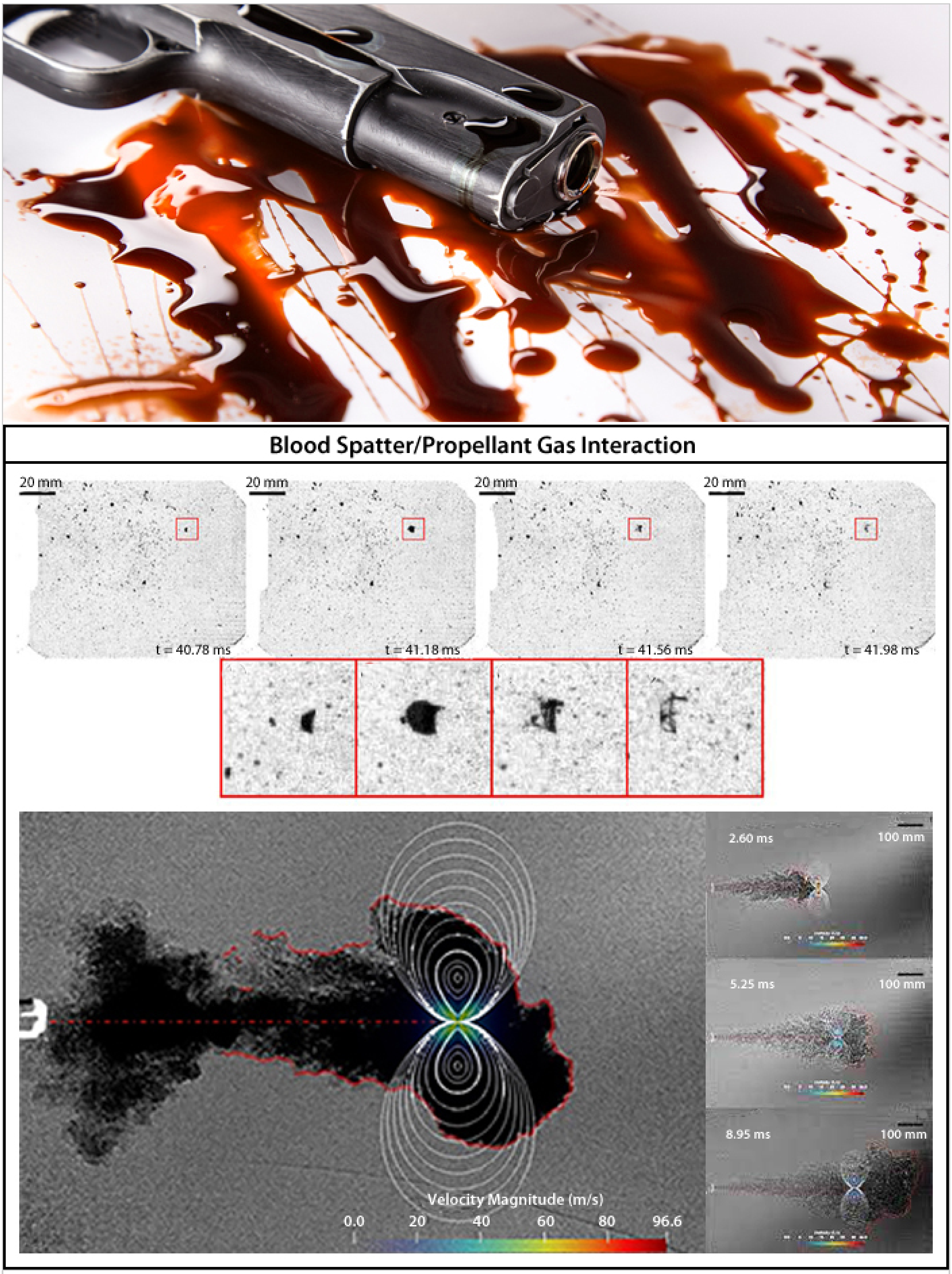
Over the last decade, several studies have indicated that propellant gas can interact with blood back spatter, potentially changing the size, shape, and flight direction of the blood droplets. Building upon this previous work, a team of mechanical engineers led by James B. Michael from Iowa State University and Alexander L. Yarin from the University of Illinois recently investigated the influence of propellant gases on back spatter in exhaustive detail. In their study, they first developed a theoretical framework for the behavior of propellant gas upon exiting the gun barrel. The gas travels in a vortex, a circular air current that follows in the path of the bullet. The researchers developed a series of equations to model the interaction between the gas vortex and the blood back spatter. These equations incorporate a number of variables, including the size and speed of the bullet, the distance between the gun and target, and the size and number of blood droplets within the back spatter.

Next, the researchers tested their theoretical model with a series of experiments. First, they filled a hollow foam cavity with room temperature pig blood in order to simulate a body. They fired at the target with an AR-15 rifle that had been fitted with a device called a suppressor (commonly known as a "silencer"), which decreases the sound of the gunshot by altering the speed and pressure of the propellant gas. The target was surrounded by a series of cameras and mirrors to capture the interaction of the blood back spatter with the propellant gas vortex.

Shooting distance is an important factor in the interaction between propellant gas and blood. The researchers explored how this affected matters by shooting at the target from distances of 65 centimeters (cm), 125 cm, and 300 cm (roughly, two feet, four feet and 10 feet). When they fired the rifle from 65 cm, the gases reached the blood back spatter within 5 milliseconds (0.005 seconds). At this point, the blood mostly consisted of solid streams, which were broken up into droplets by the gas vortex. Some of these droplets were also made to reverse direction toward the target. When the rifle was fired from 125 cm, the gas vortex encountered the blood after roughly 20 milliseconds. At this point the blood stream had already begun to break up into droplets, many of which were pushed back toward the target by the gas vortex. The gas also caused some of these droplets to break up into even smaller droplets, in a process called secondary atomization. Finally, when the rifle was fired from 300 cm, the gas vortex arrived too late to interact with any blood droplets, which had already coated the surfaces surrounding the target. The results confirmed the expectation that the distance between the gun and the target strongly influences the extent of the interaction between propellant gas and blood back spatter.

Gas Plume

The researchers also conducted a series of experiments to track the course of the propellant gas as it exits the gun barrel. In addition to the suppressor, they also fitted the AR-15 with a compensator, a device designed to reduce recoil, and a muzzle brake, which helps prevent the barrel from rising up after the trigger is pulled. The researchers also tested a 9-millimeter (mm) pistol, both without any attachments and with a suppressor. This time, a series of cameras and mirrors were positioned to capture the evolution of the propellant gas vortex.



Top: Shutterstock/Bottom: Gen Li, Nathaniel Sliefert, James B. Michael, and Alexander L. Yarin/*Physics of Fluids*/M. Bank

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The researchers observed some stark differences between the five different firearm configurations. For example, the propellant gas traveled farthest from the suppressed rifle, to a total distance of 0.7 meters (about two feet). The gas also expanded toward the target more quickly from the suppressed rifle than the rifle with a muzzle brake. However, the gas expanded radially (perpendicular to the path of the bullet) at roughly the same speed with the suppressor or muzzle break. For the pistol, the addition of a suppressor also reduced the radial spread of the propellant gas, but did not change the speed of spread toward the target. The experiments showed that modifications to the barrel of a firearm have to be considered in attempts to reconstruct what happened.

The study confirmed that firearm propellant gas can significantly alter the size, number, and final resting position of blood back spatter droplets. If the firearm is close enough to the target, the gas vortex can reverse the flow of back spatter so that the blood lands on or behind the target; this can result in potential confusion of back and forward spatter. The speed and direction of expansion of propellant gases also depends heavily on the type of firearm and ammunition, as well as any modifications made to the barrel. These findings introduce some additional challenges to the field of BPA, but also provide an opportunity to improve its accuracy.

Discussion Questions

How might these recent findings impact prior murder trials in which BPA was presented as evidence?

Journal Articles and Abstracts

(Researchers' own descriptions of their work, summary or full-text, on scientific journal websites.)

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Keywords

forensics, bloodstain pattern analysis (BPA), blood splatter, back spatter, forward spatter, propellant gas, James B. Michael, Alexander L. Yarin