

# Blood Spatter Reading: How Bloodstain Pattern Analysis Works

If you're flipping channels one day and come upon a crime scene as depicted on one of the many TV shows that focus on forensic science -- like "CSI" or "Dexter" -- you may have noticed something that seems pretty unusual. Amongst the technicians dusting for fingerprints and collecting hair fibers at the murder scene, the camera pans on an array of red strings running from the floor, the wall, the table and the sofa. All of the strings seem to meet in a specific area. Suddenly, an investigator begins recounting aspects of the crime, like when it happened, where the assault took place in the room, what kind of weapon was used on the victim and how close the assailant was to him. How could he have learned that information from strings?

The strings themselves aren't important. They're simply a tool to help investigators and analysts draw conclusions about a substance that's often found at crime scenes: **blood**. We've become used to hearing how blood samples are used to identify someone through **DNA**. But the blood itself -- where it lands, how it lands, its consistency and the size and shape of the blood droplets, or spatter -- can determine a lot of significant aspects of the crime.

Of course, analyzing blood splatter isn't nearly as simple as fictional bloodstain pattern analysts like Dexter Morgan might make it appear to be. Experts in the field often say that it's as much an art as it is a science. If there happen to be multiple victims and multiple assailants, it becomes even more complex. But a well-trained and seasoned bloodstain pattern analyst can often provide key information that leads to arrest and conviction. Let's start with the basics of bloodstain pattern analysis -- for example, what blood spatters can reveal (and what they can't).

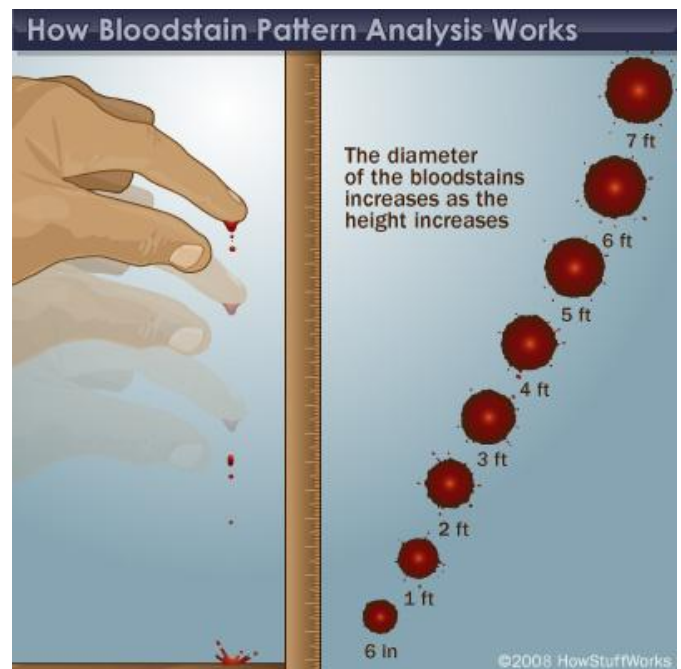
## Basics of Blood

As unpleasant as it is to deal with, when a crime results in bloodshed, the blood left behind functions as evidence for investigators. A bloodstain pattern analyst can't simply glance at drips and smears of blood and immediately tell you the who, what and when of a crime scene. Blood spatter analysis takes time and is just one piece of the puzzle when investigators are putting together the elements of a crime. However, bloodstain pattern analysis can corroborate other evidence and lead investigators to seek additional clues. After close analysis, blood spatters can indicate important information such as:

- Type and velocity of weapon,
- Number of blows,
- Handedness of assailant,
- Position and movements of the victim and assailant during and after the attack,
- Which wounds were inflicted first,
- Type of injuries,
- How long ago the crime was committed,
- Whether death was immediate or delayed.

Blood spatters can lead to the recreation of a crime because of how blood behaves. Blood leaves the body as a liquid that follows the laws of motion and gravity. It travels in spherical drops due to **surface tension**. Blood molecules are very **cohesive**, or attracted to each other, so they squeeze against each other until they form a shape with the smallest area possible. These drops behave in predictable ways when they strike a surface or a force acts upon them.

Imagine what happens when you spill water droplets on the floor. The water falls slowly to the ground, making a circular puddle. The shape and size of the puddle depends on how much water you pour, how high you hold the water glass and whether you're spilling it on carpet, wood, linoleum or some other surface. A lot of water makes a



larger puddle. If the water falls from a distance, the puddle will be smaller in diameter. A hard surface will retain more of a circular shape, while carpet absorbs some of the water and makes the edges spread.

### Dried and Clotted

Over time, blood spatters dry. How quickly this happens depends on the surface where the blood landed, how much blood is contained in the spatter, and the heat and humidity in the crime scene. The outer edges dry first. A really dry blood spatter can **skeletonize**, flaking off and leaving a ring around the original diameter of the spatter. An analyst can help to pinpoint when the crime occurred based off the dryness of the blood.

Although initially it behaves as a liquid, blood eventually begins to clot after it leaves the body. Clotting can occur within 15 minutes. If some blood spatters are more clotted than others, it can indicate that multiple blows or gunshots occurred over a period of time.

Blood spatters can also contain bits of tissue and bone. This usually points to a high-impact spatter, and the type of tissue can help to determine the depth and severity of the injuries that were sustained in the attack.

### Blood Spatter

Blood behaves in much the same way as those spilled water droplets. A **low-velocity spatter** is usually the result of dripping blood. The force of impact is five feet per second or less, and the size of the droplets is somewhere between four and eight millimeters (0.16 to 0.31 inches). This type of blood spatter often occurs after a victim initially sustains an injury, not during the infliction of the injury itself. For example, if the victim is stabbed and then walks around bleeding, the resulting drops are a type of low-velocity spatters known as **passive spatters**. Low-velocity spatters can also result from pools of blood around the body of a victim and **transfers** (impressions left by weapons, or smears and trails left by movement). It can occur with some injuries, such as bleeding sustained from a punch.

A **medium-velocity spatter** is one that had a force of anywhere from 5 to 100 feet per second, and its diameter is usually no more than four millimeters. This type of spatter can be caused by a blunt object, such as a bat or an intense beating with a fist. It can also result from a stabbing. Unlike with a low-density spatter, when a victim is beaten or stabbed, arteries can be damaged. If they're close to the skin, the victim bleeds faster and blood can spurt from wounds as his or her heart continues to pump. This results in a larger amount of blood and a very distinctive pattern. Analysts call this phenomenon **projected blood**. If we're using the water example, a medium-density splatter might come from a high-powered squirt gun.

**High-velocity spatters** are usually caused by gunshot wounds, although they can be caused by other weapons if the assailant exerts an extreme amount of force. They travel more than 100 feet per second and usually look like a fine spray of tiny droplets, less than one millimeter in diameter. Bullet wounds are unique because they can have both back and front spatters, or just back spatters. This depends on whether the bullet stopped after entering the victim's body or traveled through it. In most cases, the back spatter is much smaller than the front spatter because the spatter travels in the direction of the bullet.

Analysts always look for **voids**, or empty places in the spatters that indicate that something (or someone) caught the spatter instead of the surrounding surfaces. In the case of a high-density spatter, this may mean that the assailant got some of the victim's blood on himself or herself. Sometimes, a blood spatter can look like it was high velocity when it was actually a medium- or low-velocity spatter. Cast-off droplets can fall from larger drops of blood. A savvy analyst looks for larger drops of blood among the many tiny drops to see if they are castoffs. These types of droplets are also found often on places like ceilings when the rest of the spatters are concentrated elsewhere.

Blood spatters can also overlap each other, which can show which gunshot or stab wound took place first. Size and the force of impact are only two aspects of determining information about blood spatters. Next, we'll look at the shapes of spatters and how analysts use strings, trigonometric functions and computer programs to map out a blood-spattered crime scene.



## The Way of the Gun

If a gunshot occurred at close range, the victim might have **stippling**, or burns on his skin from gunpowder. Shots fired at very close range can also cause **internal muzzle staining**. When this happens, the victim's blood is sucked back into the gun's muzzle by the cooling of the explosive gases that are released when a shot is fired. Testing the gun's muzzle for blood can provide an additional clue to solve a case.

## The Physics of Blood Spatter

Blood is a water based substance, creates property of blood known as cohesion. **Cohesion** is where molecules of the same substance are attracted to one another. This affects another property called surface tension. **Surface Tension** is where molecules on the top layer of a liquid do not want to separate from one another, causing them to form a "false skin" on the surface of the liquid. This surface tension does several things that affect the behavior of liquids like water and blood. It causes the liquid to form a sphere when falling, and to coalesce when the sphere is shattered in order to form new, smaller spheres.

**Passive drops** are drops that fall on their own due to the force of gravity on the source of the blood. In the case of passive drops, the size of the drop plays a role in the size of the spatter.

- Bigger drop = Bigger SPATTER

Increasing **velocity** of the drop also causes an increase in the diameter of the spatter in passive drops of blood. Passive drop increases velocity as it falls due to effects of gravity. Velocity increases when drops fall from greater heights, however, spatter will not become larger at heights above 7 feet. Droplet reaches **TERMINAL VELOCITY** due to friction. Increase VELOCITY also creates:

- Increased SPIKES,
- Increased SATELITES.

There are four phases of impact when a drop of blood strikes a surface. A drop will go through these same four steps any time it strikes a surface.

- **CONTACT AND COLLAPSE** - Blood droplet flattens on impact.
- **DISPLACEMENT** - Blood droplet spreads out.
- **DISPERSION** - Some particles fly off main drop at edges.
- **RETRACTION** - Particles not completely separated suck back into main drop due to adhesive forces

The patterns left by falling or projected drops of blood can help investigators determine where a crime took place. Therefore, blood drops and stains should be examined closely before the evidence is collected.

## **Shapely Drops**

The shape of a blood drop can indicate the distance from which the blood fell and the angle of its impact. However, very few studies have been done on the patterns produced when blood impacts a surface. Therefore, a thorough forensic scientist will carry out his or her own experiments on the shape of blood droplets. To be accurate, this scientist will conduct the tests under conditions very much like those found at the crime scene.

While a droplet is falling, it is primarily spherical shape. This is surprising to some people, who may have visualized droplets as tear shaped, as cartoonists often draw them. The smaller the droplet, the more spherical its shape during fall.

## **Drop Acceleration**

As a drop falls through the air, it accelerates until it reaches a constant or terminal velocity. Measurements have shown that a blood drop, resulting from dripping at a height of 15 feet, has a volume of about 0.05-ml and falls at a velocity of about 25 feet per second. Smaller drops have a terminal velocity that is less than 25 feet per second, and larger drops have a terminal velocity that is greater than 25 feet per second. Therefore, an individual blood droplet can give an investigator the following useful information:

- The droplet's speed at time of impact,
- The direction of the droplet's travel,
- The approximate size of a blood drop.

## Round Drops

If you examine a blood droplet that struck a surface straight-on (at a 90° angle from the surface), the droplet is generally round. Straight-on impacts on hard, smooth surfaces produce round droplets with smooth edges. Higher velocities and rougher surfaces produce drops with more ragged edges.

## Elongated Drops

The angle of impact of a droplet affects the droplet's shape. When the angle of impact is 90°, the droplet is round. However, droplets that fall on surfaces at an angle that is greater than 90° have elongated shapes. The larger the angle, the more elliptical the droplet.

## Dripping and Spraying

Blood drops can be produced in several ways. A droplet that forms slowly, as in a dripping wound, has a volume of about 0.05-ml. However, smaller droplets are produced during active situations, such as fights and beatings. Blood droplets as small as an aerosol spray indicate that the wound was produced by a powerful force, such as a gunshot or an explosion.

## Stringing, Sine and Spatter Shapes

The technique of "stringing" -- attaching strings to each spatter to see where they converge -- is just one way to determine the **area of convergence**, or source of the blood. Most TV shows, like "Dexter," focus only on the analyst looking at the strings and making statements about the crime, not on the process involved. In the stringing method, which is still used by many analysts, the analyst documents the location of each spatter using the coordinate system. Then, he or she establishes a **level line** to show how the spatter is oriented in relation to the floor and ceiling.

Using elastic string, the analyst draws lines from each spatter through the level line. Then, he or she uses a protractor on the level line in the area where the strings converge to determine the angle of flight for each spatter. If the spatters are mostly on a wall, the analyst can measure the distance from the area of convergence to the wall to find out where the victim was located.

Some analysts use trigonometric calculations to find the area of convergence, which basically means that they use triangles to figure it out. The measurements of the blood stain become the sides of a right triangle. The length of the stain is the triangle's hypotenuse, and its width is the side opposite the angle the analyst is trying to find.

First, the analyst has to locate each spatter and measure its length and width using a scale, a ruler or calipers. Then, he or she computes the angle using this formula:

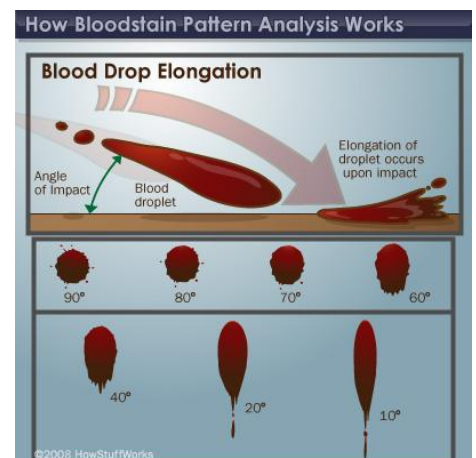
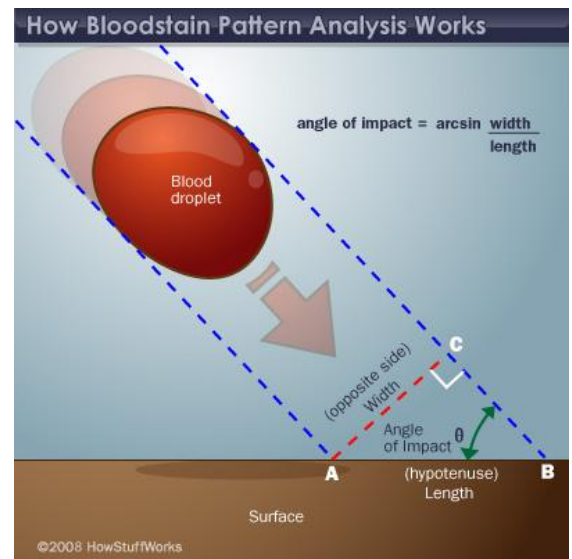
$$\text{angle of impact} = \arcsin (\text{opposite side/hypotenuse}) = \text{Width} \div \text{Length of Spatter}$$

Here's what an analyst has to do to for this to work:

- Measure the length and width of the splatter.
- Divide the width of the splatter by its length.
- Determine the **arcsin** of that number, typically using a calculator with an arcsin function.

A drop of blood that fell perfectly vertically, or at a 90-degree angle, will be round. As the angle of impact increases, the drop of blood gets longer and develops a "tail." This tail points in the direction that the drop traveled, but its length isn't part of the measurements.

The greater the difference between the width and length, the sharper the angle of impact. For example, imagine a bloodstain 2 millimeters wide and 4





millimeters long. The width divided by the length is 0.5. The arcsin of 0.5 is 30 -- so the blood hit the surface at a 30-degree angle. In a bloodstain that is 1 millimeter wide and 4 millimeters long, the ratio between them is 0.25. In this case, the blood hit the surface at about a 14-degree angle.

A third method involves taking the length and width of each blood spatter as well as other measurements of the area and putting them into a computer program, such as No More Strings. These programs create three-dimensional models and animations of the crime scene and show the area of convergence. When used to present evidence, computer programs can be more compelling and convincing than jargon-filled expert testimony or two-dimensional photographs.

### Becoming a Bloodstain Pattern Analyst

The field of bloodstain pattern analysis requires knowledge of math, physics, biology and chemistry. Students in Criminology and Criminal Justice learn about bloodstain pattern analysis in forensic science classes or classes specifically on blood spatter. But most analysts begin as law-enforcement officers who learn on the job, acquire certifications and take courses, workshops and seminars. Many train in bloodstain pattern (or blood spatter) analysis through the International Association of Bloodstain Pattern Analysis (IABPA). The IABPA developed criteria for the Basic Bloodstain Pattern Analysis Course, an introductory 40-hour course on the subject. Other organizations, such as the International Association for Identification (IAP), offer workshops and seminars as well as advanced courses which lead to certification in blood spatter analysis. The Royal Canadian Mounted Police and the Ontario Police College both offer bloodstain pattern analysis understudy programs to law-enforcement officers. The latter program is open to international candidates.

### History of Blood Spatter Analysis

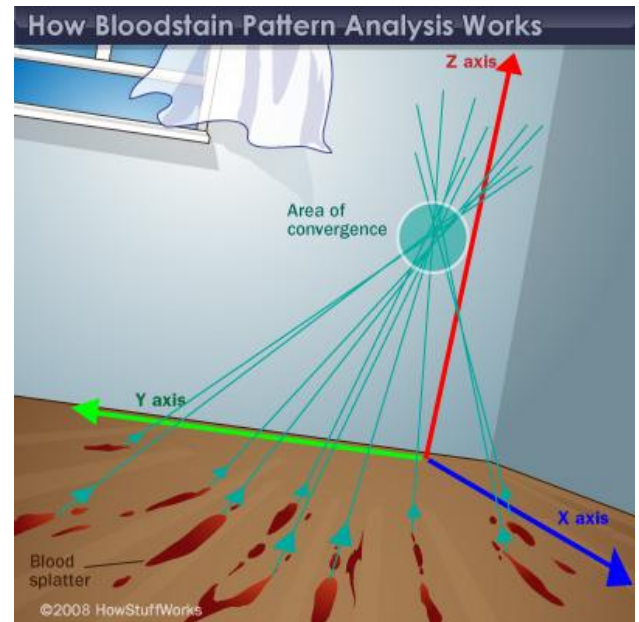
Although bloodstain pattern analysis has been studied since the late 1890s, investigators haven't always recognized how valuable it can be. The first known study of blood spatters occurred at the Institute for Forensic Medicine in Poland, by Dr. Eduard Piotrowski. He eventually published the book "Concerning the Origin, Shape, Direction and Distribution of the Bloodstains Following Head Wounds Caused by Blows." Cases that included the interpretation of blood spatters didn't appear until 50 years later.

In the highly publicized case of the State of Ohio v. Samuel Sheppard, an affidavit concerning blood spatter evidence was entered by Dr. Paul Kirk. This 1955 case marked one of the earliest instances of the legal system recognizing the importance of blood spatter analysis. Dr. Kirk showed the position of the assailant and the victim as well as showing that the assailant struck the victim with his left hand. The next significant person in the field was Dr. Herbert MacDonell, who published "Flight Characteristics of Human Blood and Stain Patterns" in 1971. MacDonell also trained law-enforcement in blood spatter analysis and developed courses to continue to train analysts. In 1983, he and other attendees of the first annual Advanced Bloodstain Institute founded the International Association of Bloodstain Pattern Analysts (IABPA). Since then, the field of bloodstain analysis has continued to grow and develop. It has now become standard practice for law enforcement to include during crime-scene investigation.

One infamous case that comes to the mind of many people when thinking about blood spatter analysis also includes a line that became a catchphrase (thanks to Meryl Streep in the movie "A Cry in the Dark" and Elaine Benes on "Seinfeld"): "The dingo ate my baby."

### Bloodstain Pattern Analysis in Action: The Chamberlain Case

In August 1980, the Chamberlain family was camping near a rock formation called Ayers Rock in Central Australia. Lindy



Chamberlain put two of her children, 4-year-old Reagan and 10-week-old Azaria, to bed in their tent. When she returned, she cried "The dingo took my baby!"

According to Lindy, when she got to the tent she saw a dingo dragging something out of it. She wasn't close enough to see what it was, but when she checked on the children she saw that Azaria was missing. As the cry went out, she and her husband Michael, along with other campers, began searching for Azaria. A nearby camper, Sally Lowe, went into the tent to check on the still-sleeping Reagan. Seeing a small pool of wet blood on the floor of the tent, she realized that Azaria was probably already dead.

When the head park ranger arrived, she showed him the blood as well as a torn and bloody blanket and bloodstained items in the tent. Police officers took the blanket and found bloodstains on the tent, but didn't take the bloodied clothes of the Chamberlains until long afterwards.

When a tourist found the baby's jumpsuit near a dingo lair, it was only slightly torn and bloody, but the snaps were still mostly closed. It was pleated down as if it had been pulled off. The baby had been wearing other clothes that weren't found. A police officer arrived on the scene, and as one tourist looked on in amazement, he picked up the bloody jumpsuit and folded it. After a TV station crew showed up, a reporter kept stating that the jumpsuit was found that way.

This continued to create more suspicion about the Chamberlains' involvement in Azaria's death. The police claimed to have found bloodstains matching Lindy Chamberlain's blood group in a cave near Ayers Rock. Initially, the small amount of blood found in the tent was suspicious as well; only later testing of the bassinet mattress showed that it had been saturated with enough blood to have resulted in the death of a baby. Fluorescent examination of the jumpsuit showed that a bloody mark consistent with the action of slitting a throat was present.

Throughout the case, the local police improperly handled blood spatter and other evidence. They didn't photograph the scene or attempt to preserve materials found there, which essentially rendered many of the conclusions that they reached invalid. However, expert testimony proved to be enough to convict Lindy Chamberlain of murder and her husband of being an accessory to murder. Three years later, after another piece of Azaria's clothing was found, Lindy was released. The case officially remains unsolved.

The Azaria Chamberlain case shows what can happen when law enforcement isn't trained in blood spatter analysis. Once the scene is changed and clothing is washed, there's no way of getting back that evidence. If the police had properly conducted their investigation, the Chamberlains may have remained incarcerated, or they may have been able to definitively prove that a dingo ate their baby.

For lots more information on bloodstain pattern analysis and all things crime-related, check out the links on the next page.

