BLOOD Interpretation at Crime Scenes

By Louis L. Akin, LPI

Key Words: blood spatter analysis, crime scene analysis, crime scene reconstruction, blood spatter velocity, blood spatter patterns

CME CREDIT CE CREDIT

This article is approved by the following for continuing education credit:

ACFEI provides this continuing education credit for **Diplomates**.

ACFEI provides this continuing education credit for **Certified Medical Investigators** who are required to obtain 15 credits per year to maintain their status.

ACFEI is accredited by the Accreditation Council for Continuing Medical Education (**ACCME)** to sponsor continuing medical education for physicians. ACFEI designates this educational activity for a maximum of 1 hour in category 1 credit towards the AMA Physicians Recognition Award.

Abstract

Medicolegal investigators (MIs) are responsible for being educated, trained, and proficient in performing their duties as criminalists and crime scene technicians. This article is written to better educate MIs from various agencies on the basic principles of blood spatter interpretation. Blood spatter interpretation is an important part of contemporary crime scene investigations. While not every MI needs to become an expert, every investigator should at least understand the fundamental principles and procedures in order to be able to correctly record data at crime scenes for later interpretation by blood spatter analysts.

The medicolegal investigator (MI) plays a critical investigative role at a crime scene as he or she performs a meticulous examination of the body. At the crime or accident scene, an MI gathers evidence to determine the cause, mechanism, and manner of death and preserves the evidence. Generally, a body and the evidence found on it are in the custody of the MI while the overall crime scene is the responsibility of the law enforcement criminalists and crime technicians. However, these fields overlap, and the evidence at the scene, whether on the body or in contiguous areas, is used to determine what occurred.

Ultimately, it is the medical examiner (ME) or coroner who decides whether the manner of death was natural, accidental, suicidal, homicidal, or unknown (sometimes called equivocal) and who determines the proximate cause and mechanism of death. The ME relies on the evidence gathered by the MI at the scene in making that decision.

Blood spatter interpretation may be compared to tracking. It may take considerable training to reach the level of a professional tracker who can, for example, determine that a footprint was made 2 days earlier by a running 183-pound male with bunions. That level of training or expertise is not required to be able to look at a footprint and determine which way the person was walking—to do this, you just pick out the heel and toe. In the same way, while an expert may

Spatter

be able to see things in the blood that the investigator does not, an investigator can learn to determine where a victim was positioned by looking at the blood spatter at a scene the same way he or she would look at a footprint to determine which way the footprint is going.

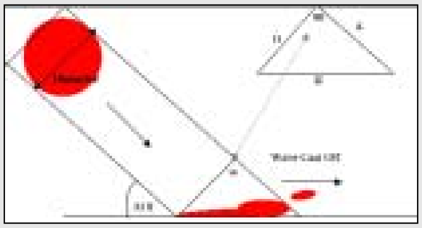
A basic understanding of the principles of blood spatter analysis will allow the investigator to correctly collect blood stain data at the scene and intelligently converse with the ME, homicide detectives, and blood spatter experts regarding the blood evidence. This understanding is important, because the interpretation of blood spatter patterns and other evidence at crime scenes may reveal critically important information such as the positions of the victim, assailant, and objects at the scene; the type of weapon that was used to cause the spatter; the number of blows, shots, stabs, etc. that occurred; and the movement and direction of the victim and assailant after bloodshed began. It may also support or contradict statements given by witnesses.[1]

The crime scene analyst may use the blood spatter interpretation to determine what events occurred; when and in what sequence they occurred; who was, or was not, there; and what did not occur. The lists of precisely what information can be learned by the interpretation of blood stain patterns are similar for Bevel and Gardner,[2] James and Eckert,[3] Hueske,[4] Slemko,[5] and Sutton.[6]

The Theory: The Teardrop Versus the Blood Drop

Experiments have shown that blood tends to form into a sphere rather than a teardrop shape when free falling or projected in drop-size volumes (approximately 0.05 ml or 20 drops per milliliter, though some are larger and some are smaller).[7] The formation of the sphere is a result of surface tension.[8] Fresh blood is slightly more viscous than water and tends to hold the sphere shape in flight. The sphere shape is critical to the calculation of the angle of impact (AOI) of blood spatter, which is used to determine the point or area from which the blood originated, commonly referred to as the point of hemorrhage (POH) or the point of origin. (Note: this author prefers to use the term *point of hemorrhage* to distinguish the area from which the blood was disgorged from other *points of origin*, the latter phrase being a widely used term in blood spatter, ballistics, and crime and accident scene investigation and reconstruction. Although most experts use the word *point*, the word *area* is a more conservative one to use.)

Figure 1. Side view of blood drop in air and hitting surface.



Using Pythagorean Trigonometry to Determine the Angle of Impact, Point of Convergence, and Point of Hemorrhage

Generally, a single spatter of blood is not enough to determine the POH at a crime scene. The determination of the AOI and placement of the POH should be based on the consideration of a number of spatters. The process for determining the AOI is not complicated. When a sphere of blood strikes a flat surface, the diameter of the sphere in flight will equal the width of the stain on the surface (which is equal to the opposite side of a right triangle) as illustrated in Figures 1, 2, and 3.

To find the POH, one must first determine the two-dimensional point of convergence (POC). The POC is the intersection where lines drawn through the center of the individual stains meet (at the X - Y axis

Figure 2. Top view of blood drop in air and the stain it leaves after it hits a flat surface.

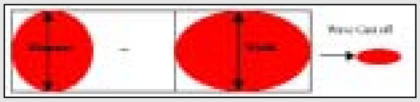


Figure 3. Central axis.

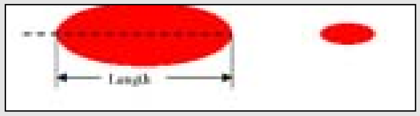
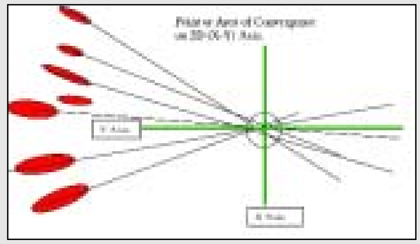


Figure 4. Point of convergence.



intersection). It is determined by drawing lines or strings through the long axis of individual spatters, as illustrated in Figure 4.

The next step in the process is to determine the AOI for representative bloodstains.

To Determine the Angle of Impact (AOI):

i. Where opposite = width (W) and hypotenuse = length (L)
ii. Angle of impact = inverse of ARCSIN of W/L ratio
a. First calculate ratio (W/L)
b. Then SIN - 1 (2nd key) to get degree of AOI.

For purposes of providing visual illustration to a jury, strings can be used to demonstrate the AOI and POC, as shown in Figure 5.

The Perpendicular or Z Axis

Once the POC and the AOIs have been established, the next step is to locate the POC three-dimensionally, which will require a vertical axis that is ordinarily called the Z or perpendicular axis. The perpendicular axis is the same as the long axis of a standing person. The location where the strings or imaginary lines of the trajectories of the blood stains meet on that axis will approximate the point or area from which the blood was disgorged, dubbed the POH. (See Figure 6.)

While the POC is the two-dimensional intersection of the X and Y axes, the POH is located above the POC on the vertical axis 90° perpendicular to the floor. It is the point from which the blood hemorrhaged or was disgorged from the body. In Figure 7, the POH is determined by calculating the angle that the blood struck the wall and drawing a line from each blood spot back to the Z axis.

The formula to determine the POH on the vertical (Z) axis is similar to the one used to establish the AOI, except that the TAN function of the calculator is used. First, measure the distance from each blood stain along its central (Y) axis to the POC. Second, use the calculator to obtain the TAN of the degrees AOI. Third, multiply the TAN of the AOI by the distance measured along the Y axis.

To Determine Point of Hemorrhage (POH) on the Vertical (Z) Axis

For each representative bloodstain:
Where distance from bloodstain to AOC = Y axis,
TAN of 0 (AOI) x Y = POH.
Example:
AOI where O = 1.5 mm and H = 3 mm, then ratio = 0.05
Take -SIN 0.5 and the 0 = 30°
TAN of 30° = 0.57735
And where length of Y axis (distance to POC) is 90 cm, then
POH = TAN of 0 (30°) x Y (90 cm)
Calculate as TAN (30°) = 0.57735 x 90 cm = 51.961
Answer: POH = 52 cm,
Then 52 cm / 2.54 = 20.4724409 inches.
Measure 52 cm (or 20.5 inches) from the floor (X-Y axis) up the Z axis to arrive at the approximate point where the blood left the body.

Velocities of Blood Spatter

There are three classifications of velocities of blood patterns, with a large undefined

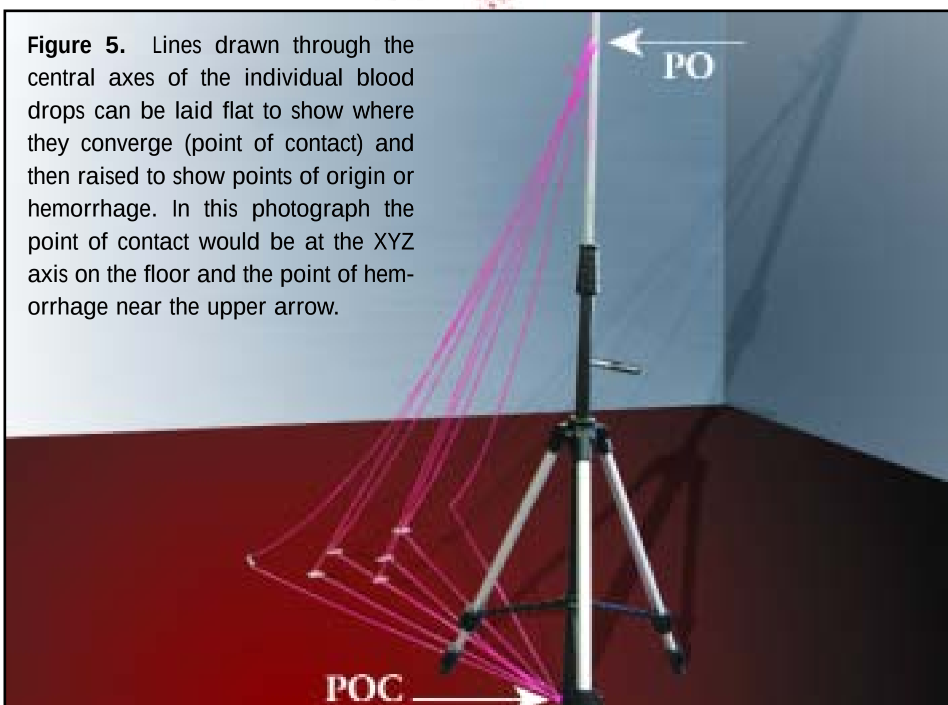


Figure 5. Lines drawn through the central axes of the individual blood drops can be laid flat to show where they converge (point of contact) and then raised to show points of origin or hemorrhage. In this photograph the point of contact would be at the XYZ axis on the floor and the point of hemorrhage near the upper arrow.

Figure 6. The perpendicular or Z axis.

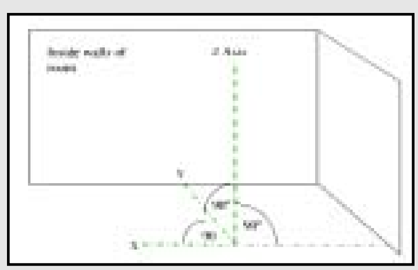
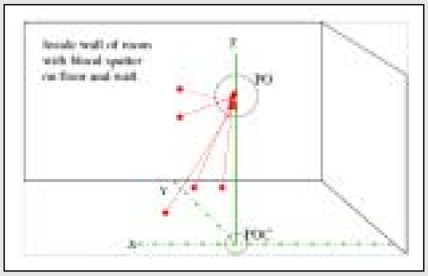


Figure 7. Lines converge in the third dimension at the point of hemorrhage on the Z axis.



gap between the medium-speed and high-speed velocities. This gap is a result of the velocity classifications having grown out of the blood stains found at crime scenes that have limited causes (i.e., gravitational pull), blunt instrument acceleration, and high speed misting as a result of gun shot wounds. The velocity is the force causing the blood to move, rather than of the speed of the blood itself, and is measured in feet per second (fps). High velocity blood, for instance, may be caused by a bullet moving at 1800 fps.

Low Velocity. Low velocity stains are produced by an external force less than 5 fps (normal gravity); these stains are 3 mm and larger. They are usually the result of blood dripping from a person who is holding still, walking, or running, or sometimes from cast-off. Dripping blood often falls at a 90° angle and forms a 360° stain when it hits a flat perpendicular surface, depending on the texture of the surface. Spines can be caused by drops repeatedly landing in the same place, by the distance the drop falls, or by the surface upon which the blood lands. Low velocity blood may also be found in the trail of a person who is bleeding, and larger pools of blood may indicate where the person paused.

Medium Velocity. Medium blood spatter is produced by an external force of greater than 5 fps and less than 25 fps. The stains generally measure 1-3 mm in size. They are often caused by blunt or sharp-force trauma (i.e., knives, hatchets, clubs, fists, arterial spurts, and sometimes cast-off).

Figure 8. Classic 90° angle blood drops caused by gravity. The spines were caused by the relatively textured brown wrapping paper. Glass may have produced perfectly smooth edges.

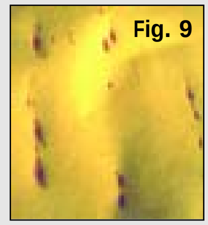
Weapon Cast-Off. Weapon cast-off, or just plain cast-off, is often found at crime scenes where blunt or sharp instruments were used as the weapons of attack. Cast-off blood is sometimes confused with arterial spurts. Cast-off blood is flung off the weapon (such as an axe, knife, or club) as a result of centrifugal force as the weapon is swung back over the attacker's head. Cast-off spatter tends to be oval or elliptical in shape as the weapon is being swung through an arc, but becomes more round as it strikes at a 90° angle at top-dead center over the attacker's head. It may be classified as low or medium velocity depending on the drop size. See Figures 10 and 11.

Arterial Spurts. Arterial blood graphically displays the pumping of the left ventricle of the heart in squirted arcs (See Figure 12). As the ventricle contracts, the blood is squirted out of the artery as water from a water pistol. It starts with a low pressure that increases and then decreases, causing the arcing pulse that results in the distinctive blood pattern. Arterial blood spatter does not lead far because the bleeder loses blood volume quickly and goes into shock or dies. Occasionally, however, victims have covered surprisingly long distances while bleeding arterially.

The arterial blood pattern may be confused with cast-off blood patterns or obfuscated by layover patterns. The bleeder may still be under attack while bleeding arterially and may sustain further bleeding wounds or may be bleeding

Figure 9. Low velocity blood from the simulation of a bleeding person who is walking or running. Note that the blood drops "point" in the direction of travel. This image is of cow blood on brown wrapping paper. These are classic angled drops with waves and probably impacted the surface at roughly 60°.

Figure 10. Cast-off blood pattern.



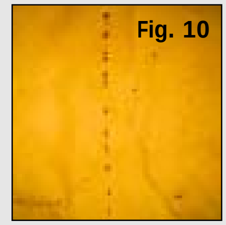
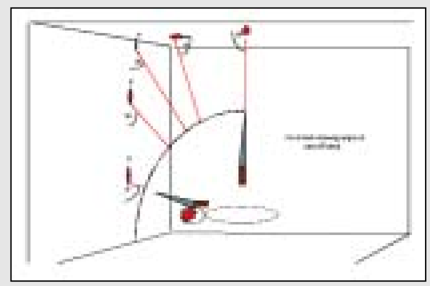


Figure 11. Drawing of cast-off blood from the arc of a chopping, stabbing, or clubbing motion. Note the 90° round spatter at the top-dead-center position over the attacker's head.



from previous wounds. The arcs are commonly accompanied by bloody hand prints and other forms of transfer blood such as swipe and wipe. The bleeder may fall against the blood spatter and smear the pattern (wipe) or smear blood from his or her body or clothing onto the surface (swipe). These are but two forms of transfer blood that may be confusing in the picture at crime scenes and even more confusing in photographs of crime scenes.

Most medium velocity blood will be in the form of patterns created by blood flying from a body to a surface as a result of blunt and sharp trauma. It may be the result of punching, stabbing, or bludgeoning with a blunt instrument.

In Figure 13, the pattern has a void where the victim's head would have been located during a beating. Such a void space may be created by anything that blocks the blood from falling on the surface where it would otherwise have land-

Figure 12. Author Louis Akin mimics arterial spurting on brown wrapping paper. These spurts were produced using a hypodermic syringe and cow blood. While this photograph shows the arc pattern, the amount of blood from actual arterial spurts is usually greater and messier. The arcs may staircase downward as the victim collapses to the floor.

Figure 13. Medium velocity blood as from a bludgeoning.

Figure 14. High velocity gun shot blood spatter leaves a mist-like appearance.

ed. The object creating the void may be the victim, the attacker's body, or a piece of furniture that was moved in order to stage the scene.

Locard's Principle of Exchange states that whenever two objects come into contact, some of the matter of each object is transferred to the other. Locard's principle has become a cardinal principle of crime scene analysis and reconstruction. If a person enters a crime scene and leaves, he or she leaves something of him or herself at the scene and takes something from the scene with him or her. In many cases, the void is what the attacker leaves, and the blood spatter that would have filled the void is what he or she takes away from the scene.

High Velocity. An external force greater than 100 fps produces high velocity blood spatter, and the stains tend to be less than 1 mm. The pattern is sometimes referred to as a mist. High velocity patterns are usually created by gunshots or explosives but may also be caused by industrial machinery or even expired air, coughing, or sneezing. In any case, the spatter tends to be tiny drops propelled into the air by an explosive force.

High velocity droplets travel the least distance because of the resistance of the air against their small mass. In gunshot wounds, the area contiguous to the wound may be showered in a mist of blood spatter and may contain pieces of tissue, but areas further away may not have any blood spatter on them or may only have tissue and blood that accompany the surface impacted.

Conclusion

Blood spatter evidence is being gathered in more cases each day as more personnel are trained in methods of photographing and collecting evidence. Blood spatter evidence is currently restricted almost exclusively to major murder cases. Since blood spatter can tell so much about what took place at the scene of a crime, it should be given more attention, even when there are witnesses and the violence was not lethal. The practice of collecting fingerprints at crime scenes spread at a slow pace when it was first introduced, but now every law enforcement department has fingerprint technicians to collect prints at scenes and experts to compare and classify those prints. In the near future, we can expect every department to have blood spatter technicians to collect the blood spatter evidence at the scene and experts to analyze it. MIs and crime scene technicians will be the personnel most likely to gather this evidence at the scene.

References

1. Stuart H. James, William G. Eckert, *Interpretation of Bloodstain Evidence at Crime Scenes,* 2nd ed. (Boca Raton, FL: CFC Press, 1999), 10-11.
2. Tom Bevel, Ross M. Gardner, *Bloodstain Pattern Analysis,* 2nd ed. (Boca Raton, FL: CRC Press, 2002).
3. Stuart H. James, William G. Eckert, *Interpretation of Bloodstain Evidence at Crime Scenes,* 2nd ed. (Boca Raton, FL: 1999).
4. Edward E. Hueske, *Shooting Incident Investigation/Reconstruction Training Manual* (Unpublished training manual, 2002).
5. J. Slemko, *Bloodstain Pattern Analysis Tutorial for Forensic Consulting.* Retrieved 2005 from: http://www.bloodspatter.com/BPATutorial.htm.
6. Paulette T. Sutton, *Bloodstain Pattern Interpretation, Short Course Manual* (Memphis, TN: University of Tennessee, 1998).
7. Stuart H. James, William G. Eckert, *Interpretation of Bloodstain Evidence at Crime Scenes,* 2nd ed. (Boca Raton, FL: CRC Press, 1999), 20.
8. Paulette T. Sutton, *Bloodstain Pattern Interpretation, Short Course Manual* (Memphis, TN: University of Tennessee, 1998), 4.

This article has been excerpted from *Step by Step Guide to Blood Spatter Interpretation at Crime and Accident Scenes for Medicolegal Death Investigators.* It appears here with changes.

About the Author

Louis L. Akin, LPI, lives in Austin, Texas, and has been an ACFEI member since 2003. He has 23 years of experience in crime scene investigation and reconstruction. Akin designed and engineered the On Scene Blood Spatter Calculator software, which automates recording and calculating blood spatter. He also authored the pocket manual *Blood Spatter Interpretation at Crime and Accident Scenes: Step by Step Field Guide for Medicolegal Investigators,* which offers a simplified method of manually collecting, recording, and preserving blood spatter data on the scene. Akin also teaches blood pattern analysis in Austin. For more information, please visit his websites at www.akininc.com and www.onsceneforensics.com .

Earn CE Credit
To earn CE credit, complete the exam for this article on page 64 or complete the exam online at www.acfei.com (select "Online CE").