Blood Pattern Analysis at Crime Scenes

By Louis L. Akin, LPI

Through a variety of schools, classes, and seminars homicide detectives and crime scene technicians or criminalists are garnering a level of expertise that has not previously existed in law enforcement. New technologies, sciences, and applied sciences are available for detectives and criminalists to use in solving crimes and apprehending offenders. Blood pattern analysis may require special schooling and expertise. However, blood pattern evidence collection is an example of an applied science that a homicide detective or first responding police officer can learn to use at a scene without having to become an expert in the field.

Blood spatter interpretation or analysis itself may be compared to tracking. It may take considerable training to reach the level of a tracker who can say that a footprint was made two days before by a pigeon towed 180 male who has bunions. It does not require that level of training or expertise to be able to look at a footprint and determine which way the person was going. Just pick out the heel and toe.

Likewise, although an expert may be able to see things in the blood pattern that the first responding officer at a crime scene doesn't a responder can preserve the evidence and take the measurements of the stains in a pattern just as he does at an accident scene. He or she could even learn to determine generally where a victim was positioned by looking at the blood spatter the same way he could tell which way a footprint is going.

A basic understanding of blood spatter analysis will also allow the first responding officer to assist in correctly collecting and preserving blood stain data at the scene. Fortunately, the principles and procedures to learn are not complicated, and while it is easier to use software to make the calculations, the basic principles can be learned from a source as brief as this article and applied by using a hand held calculator. Some critical determinations, such as establishing the point of convergence that shows where the victim was standing can be done without use of a calculator at all.

This basic 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 during the attack.
- The type of weapon that was used to cause the spatter.
- The number of blows, shots, stabs, etc. that occurred.
- The movement and direction of victim and assailant, after bloodshed began.
- It may support or contradict statements given by witnesses[i].

The investigator may use blood spatter interpretation to determine:

- What events occurred.

- When and in what sequence they occurred.
- Who was, or was not, there.
- 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[ii], James and Eckert[iii], Hueske[iv], Akin[v], and Sutton[vi].

Photography

Without a doubt, the most important thing do at a crime scene in regard to blood spatter analysis is to photograph the scene and the blood spatter. The photographs should all be made at a 90 degree angle from the surface on the blood stains are found and a scale should always be in the photograph so the viewer can tell the size of the drops in the pictures.

Traditional Determination of Velocities of Blood Spatter

The velocity of the blood spatter when it strikes a surface is a reasonably reliable indicator of the speed of the force that set the blood in motion in the first place. The velocity is that of the force causing the blood to move rather than of the speed of the blood itself and it is measured in feet per second (fps); high velocity blood, for instance, *may* be caused by a bullet moving at 900 fps, medium velocity blood spatter may be caused by a spurting artery or by a blunt instrument striking the already bloody head or limb of a victim.

Figure 1 Low Velocity

Low velocity stains are produced by normal gravity and the stains are generally 3mm or larger. It is usually the result of blood dripping from a person who is still, walking, or running, or from a bloody weapon. Dripping blood falls at a 90° angle and forms a 360° circumference stain when it hits a flat surface, depending, of course, on the texture of the surface. See Figure 1 as an example of low velocity spatter.

Figure 2 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 1-3mm in size. Blood stains this size are often caused by blunt or sharp force trauma that is, knives, hatchets, clubs, fists, and arterial spurts. They might also result from blood being cast off a weapon or other bloody object.

Most medium velocity blood found at crime scenes will be created by blood flying from a body as a result of blunt or sharp force or the body colliding with blunt or sharp surfaces. It may be the result of a punch, a stab, or a series of blows. A void space may be created by anything that blocks the blood from falling on the surface where it would have normally landed. The object creating the void may be either the victim or the attacker's body or a piece of furniture that was moved .See Figure 2 for an example of medium velocity spatter.

Figure 3 High Velocity

High velocity blood spatter is produced by an external force greater than100 fps and the stains tend to be less than 1mm. 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 far because of the resistance of the air against their small mass. See Figure 3 above as an example of high velocity spatter.

Blood Spatter Flight Characteristics

Experiments with blood have shown that a drop of blood tends to form into a sphere rather than a teardrop shape when in flight. The formation of the sphere is a result of surface tension that binds the molecules together.

Fresh blood is slightly more viscous than water, and like water it tends to hold the spherical shape in flight rather than a tear drop shape as seen in cartoons.

This spherical shape of a liquid in flight is important for the calculation of the angle of impact (incidence) of blood spatter when it hits a surface. That angle will be used to determine the point from which the blood originated which is called the Point of Origin or as this author prefers, the Point of Origin (PO)

Generally, a single spatter of blood is not enough to determine the Point of Origin at a crime scene. The determination of the Angle of Impact and placement of the POHm should be based on the consideration of a number of spatters and preferably spatters that will provide an arc of reference points in order to create a triangulation effect.

The process for determining the Angle of Impact is not complicated. When a drop of blood strikes a flat surface the diameter of the drop in flight will be equivolent to the width of the spatter on the surface as seen in Figure 4 below. The length of the spatter will be longer, depending on the angle at which the drop hit. The following diagram will help the reader to understand this concept.

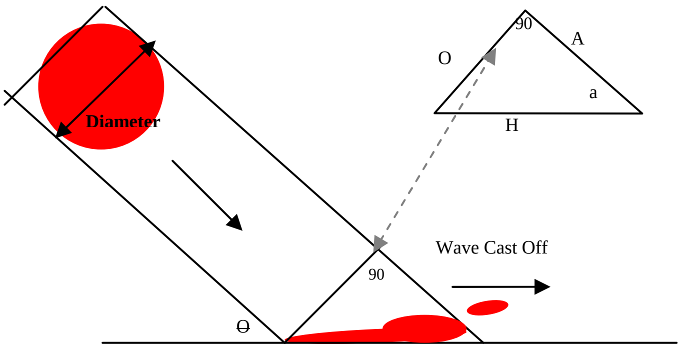

Figure 4 Side View of blood drop in air, and then striking a flat surface

Point of Convergence (POC)

For purposes of instruction, we will consider a case in which a fan shape blood pattern is found on a floor as the result of a gun shot wound to the head. When blood disperses in various directions from a wound the blood drops will tend to fan out. As the drops strike the floor, they will elongate into oval shapes. An imaginary line drawn through the middle of the oval shape lengthwise will run back to the area where the blood came from. If lines are drawn through several of the blood spatters as in Figure 5 below the lines will cross at the point where the person was standing. That point is called the Point of Convergence and will be flat on the floor (if that is where the spatter is located). Somewhere above that point is where the blood originated. If the victim was shot in the head, it may be 4-6 feet (roughly the height of an average person) above that point. Where the blood left the person's body is called the Point of Origin as previously mentioned. To find the Point of Origin (PO), first determine the two dimensional Point of Convergence (POC) on the floor as seen in Figure 2 below.

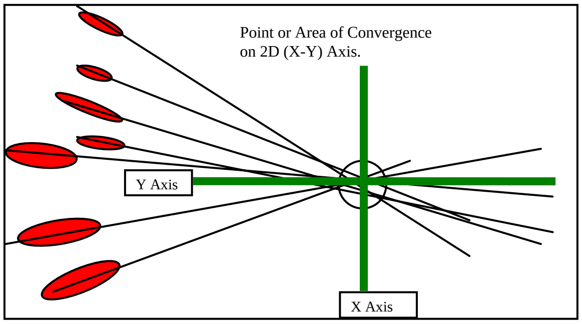

Figure 5 Lines through the central axes of the spatter cross at the Point of Convergence.

Determining the Angle of Impact (AOI)

The next step in the process is to determine the Angle of Impact (AOI) for representative bloodstains. Specialized blood spatter calculator software that performs all the calculations automatically is available from on-line vendors, but for those who do not mind doing the trigonometry all the calculations can be done on an ordinary hand held scientific calculator or even by the use of printed copies of arc sinee tables.

The Angle of Impact is the angle at which the blood drop hit the floor. It can be determined by taking the inverse arc sin of the width divided by the length ratio of an individual blood spatter.

If using software just enter the width and length into the table on the screen and the calculation will be done automatically. If using a hand held calculator, divide the length of the drop into its width, then take the arc sinee which is the second function on a hand held calculator (or just look on a trigonometric functions table) to get the degrees of the AOI.

Example:

If a drop measures 0.5 mm wide and 1.0 mm long, dividing 1. into .5 would give a ratio of .5. The arc sin of .5 is 30 degrees. Find that by using the cosecant function on the calculator, or by looking at an arc sinee table. This calculation determines that the blood drop hit the ground at 30 degrees and it is already known that it came from the Point of Convergence.

Measure the distance from the individual drop to the Point of Convergence and multiply that number by the Tangent of the Angle of Impact. This calculation (Pythagorean's Theorem) will tell how high up the spatter originated from. The following section explains this more thoroughly.

Point of Origin

The *Point of Origin* (PO) is located above the Point of Convergence (POC) on the perpendicular axis. In this case that would be 90 degrees perpendicular to the floor. It is the point from where the blood was disgorged from the body. To determine where that point is located first measure the distance from each blood stain along its central axis to the POC. Then take the TAN of the degrees AOI. Third, multiply the TAN of the AOI by the distance. Measure that distance from the floor up the perpendicular axis and you will arrive at the Point of Origin.

Conclusion

Blood pattern analysis experts can develop vast amounts of information from the patterns of blood at a crime scene. First responding officers and homicide detectives will be more aware of the value of blood spatter evidence if they understand the fundamentals of pattern analysis. Additionally, first responding officers and detectives can glean a great deal of information themselves at the scene without becoming experts and they can assist the experts later with the data that they gathered at the scene. If the blood spatter evidence is properly photographed and if accurate measurements are taken of the length and width of the individual spatters and the distance from each spatter to the Point of Convergence, the analyst can later make the necessary calculations based on that data and draw conclusions from them. If the measurements and photographs are not taken, critical information may be lost forever.

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[i] James, Stuart H, Eckert, William G. Interpretation of Bloodstain Evidence at Crime Scenes, 2nd Edition, CRC Press 1999 p10-11
[ii] Bevel, Tom; Gardner, Ross M. Bloodstain Pattern Analysis, 2nd Ed. CRC Press 2002
[iii] James, Stuart H, Eckert, William G. Interpretation of Bloodstain Evidence at Crime Scenes, 2nd Edition, CRC Press 1999.
[iv] Hueske, Edward E., Shooting Incident Investigation/Reconstruction Training Manual, 2002
[v] Akin, Louis L., *Blood Spatter Interpretation at Crime and Accident Scenes: A Step by Step Guide for Medicolegal Investigators*, On Scene Forensics, 2004 www.onsceneforensics.com
[vi] Sutton, Paulette T., Bloodstain Pattern Interpretation, Short Course Manual, University of Tennessee, Memphis TN 1998