BASIC BLOODSTAIN PATTERN ANALYSIS

Jon J. Nordby, Ph.D., D-ABMDI
Final Analysis Forensics

A. INTRODUCTION

Bloodstain pattern analysis involves the *scientific study* of the static consequences resulting from dynamic blood shedding events. A detailed study of bloodstain patterns at crime scenes often develops invaluable evidence. The distribution, size and shape of bloodstains on a victim, on a suspect, or on the walls, floors, ceilings, or on objects at the scene can help reconstruct these blood shedding events. Bloodstain pattern analysis can also help one evaluate the credibility of statements provided by a witness, a victim, or a suspect.

Physical evidence waits to be detected, preserved, evaluated, and analyzed. Herb McDonnell once said that in the course of a trial, both defense attorneys and prosecuting attorneys may lie, witnesses may lie, and the defendant certainly may lie. Yes, even the judge may lie. Only the evidence never lies. But if the evidence is not properly recognized, documented, preserved, and processed, all we have are attorneys, witnesses, defendants, and judges. Enough said.

B. CHARACTERISTICS OF BLOOD

In order to understand bloodstain evidence, one must understand some basic scientific principles.

1. When blood leaves the body as a drop, as spatter, or as a gushing flow from an artery, its behavior conforms to the laws of physics.

2. Understanding blood flows involves understanding the physical forces involved in blood shedding events.

3. As a fluid, blood has physical properties similar to the properties of water. Blood is affected by physical forces much as water is affected by physical forces.

4. Unlike water, however, blood is a pseudoplastic non-Newtonian fluid.

5. Fluids lack the ability to support a shearing stress. This property distinguishes fluids from solids. A fluid will flow under the influence of a shearing stress while a solid will not.

6. Viscosity is a form of internal friction in fluids. It results from frictional forces generated between layers of the fluid as they flow past each other. Viscosity, then, is a measure of a fluids resistance to change in shape or flow – it is colloquially referred to as a fluids ‘thickness’ or ‘thinness.’ [Water is thinner, therefore less viscous, than motor oil.]

7. Viscosity results from the electrical forces attracting the fluids molecules to each other. [Red blood cells concentrate sialic acid on their membranes producing a high negative electrical charge giving blood a higher viscosity than water].

8. Newtonian fluids maintain constant viscosity under shearing forces [ignore temperature and pressure changes for the moment]. Water is a Newtonian fluid.

9. Non-Newtonian fluids DO NOT maintain constant viscosity under shearing forces. Blood is a non-Newtonian fluid.

10. Blood's viscosity decreases with increases in blood's velocity gradient. Blood is a "shear thinning fluid."

11. Blood drops hold together in free flight through the forces of both cohesion and surface tension.

12. Cohesion is an electrical force attracting like molecules to each other. Surface tension is a force resulting from a fluid's molecules achieving the most stable low-energy configuration by minimizing exposed areas of the fluid. This phenomenon results in increased cohesive forces at the liquid's surface, in turn producing "a skin" or "a membrane" of cohesive force.

13. The forces of cohesion and surface tension cause blood drops to become and remain spherical once they fall free from their source. Cohesion and surface tension also cause the drops to resist breaking up even when striking targets such as floors, walls, body parts, or clothing.

14. Other forces affecting bloodstain patterns include adhesion and capillary action.

15. Adhesion is the force attracting unlike molecules to each other.

16. Capillary action is the force that results when the adhesive forces attracting a fluid to a surface are greater than the cohesive forces attracting that fluid to itself. When blood is drawn into any porous material it does so by capillary action. This force helps explain the concave meniscus in a test tube blood sample.

17. If the cohesive force of the liquid is greater than the adhesive force attracting the liquid to the container, then capillary action is reversed. Reverse capillary action, then, results in a convex meniscus.

18. Relative density (once called 'specific gravity') compares the ratio of the density of a given substance to the density of water. [The density of water is 1 g/cm^3] – So any substance with a density lower than water will float on water; any substance with at density higher than water will sink in water.

19. Since relative density is a ratio, it has no units. Blood has a relative density of 1.060

20. The maximum speed for a free-falling blood drop in air is 25.1 feet per second for a 0.05 ml drop. Little change in the blood drop appears from 0 to 25 feet. There will be no change in the blood drop after 25 feet because at that point, it has reached its terminal velocity. Only the target surface can change the shape or condition of the blood drop.

C. THE FORCES OF COHESION AND SURFACE TENSION IN A BLOOD DROP MUST BE OVERCOME BY SOME GREATER FORCE(S) FOR THE DROP TO SPATTER.

1. Surface texture, not distance fallen, determines the degree of blood spatter.

   a) If the surface is smooth and clean, ruptures of the surface tension do not occur and the drop will not spatter.
   b) If the surface is rough, porous or has protruding fibers, the surface tension will rupture, causing the blood to spatter.

2. Blood striking an object at angles less than 90 degrees produces a tear drop shape. A 90-degree impact angle will yield a circular shape.

3. In tear-drop stains, the sharp end points in the direction of travel. This pointed end indicates the blood drops forward direction of travel prior to striking the surface.

4. When blood forcefully strikes a surface at sharp angles, a smaller droplet is cast-off from the larger parent drop much like a large breaking ocean wave issues smaller water volumes which travel up the beach as surf. The smaller "wave cast-off" droplet travels closely to the surface and in a very short distance, begins to streak the surface.

D. FOR BLOOD DROPS TO DIVIDE, ENERGY MUST BE APPLIED TO OVERCOME COHESION AND SURFACE TENSION.

1. Generally, the **higher** the energy, the **greater** the division and the **finer** the spatter.

2. Generally, the lower the energy, the less the division and the bigger the spatter.

E. BLOOD DRIPPING INTO BLOOD

1. Blood that drips into blood results in small round satellite spatters, usually from 0.1 to 1.0 millimeters in diameter, surrounding the center of the bloodstain.

2. Commonly seen when a blood source continually drips into a pool of blood.

F. BLOOD TRANSFER PATTERN

1. Transfer Pattern - occurs when a wet bloody surface contacts a second unstained surface creating recognizable mirror image or at least a recognizable portion of the original surface.

2. Examples of common transfer patterns:

   a) Clothing patterns which reproduce fabric weaves
   b) Shoe print and hand print transfers

3. Swipe Pattern - the transfer of blood onto a surface not already contaminated with blood. One side is usually feathered which indicates the direction of travel.

   a) One common pattern at scenes is a hair swipe - a long thin fine line transfer
   b) Another common pattern at scenes is a clothing swipe

4. Wipe Pattern - created when an object moves through blood that has not completely dried and moves, removes, or otherwise alters it.

5. Smear Pattern - a large volume of blood, at least 0.5 ml, which has been distorted so much that further classification is not possible.

6. Smudge Patterns - another reference to a bloodstain that has been distorted to such a degree that further classification is not possible.

H. CAST-OFF

1. During a beating with an instrument which produces the bleeding, blood will not normally collect on the surface of the instrument from the first strike.

2. On subsequent strikes at the same location, blood will adhere to the instrument since it now strikes a blood source. When the instrument is raised or swung backward, its movement allows small drops of blood to be released from its surface.

    a) Some of these small drops will strike a surface, often a ceiling, at a 90-degree impact angle.
    b) As the instrument continues to swing backward, the movement accelerates and additional blood droplets will be cast-off the surface of the instrument. These drops will approximate a liner pattern.
    c) The small drops will strike at increasing acute angles and become elongated.
    d) When the swing of this bloody instrument is interrupted, the resulting patterns are called "cessation cast-off."

3. The movement and the number of swings can often be documented by examining the cast-off pattern.

    a) The instruments range from hammers, bats, tools, and hands, to just about anything that can be used as weapon – the only requirement is that the object becomes bloodstained during multiple impacts.
    b) Cast off bloodstains also can result from multiple stabbings.

B. EXPIRATED BLOODSTAINS

1. This type of pattern usually occurs when blood is expelled through the mouth, nose, or some perforating airway injury.

    a) The victim may have had a gunshot wound which results in coughing up blood through his mouth and nose.
    b) The victim may also have internal injuries which cause blood to be coughed up or exhaled.
    c) CPR or other resuscitative efforts may also produce such stains.

2. The bloodstains *may* have tiny air bubbles in them, visible even after they dry. Magnification is often required to see these bubbles. They *may not* be seen.

3. This bloodstain pattern could be confused with other minute trace evidence, so it is important closely to examine the "bloodstains" and to perform presumptive tests where possible.

C. PROJECTED BLOOD STAINS OCCUR WHEN A LARGE VOLUME OF BLOOD IS PROPELLED TOWARD AND STRIKES A SURFACE.

1. This type of pattern, also called arterial spurting, usually occurs when an artery is damaged and the blood spurts or gushes from the wound in large volume pulses. It continues spurting as long as the heart continues beating.

2. Large drops striking a vertical surface decelerate from air resistance and produce a pattern without spines. The drops strike the surface and then characteristically drip or run downward due to their large volume.

3. This blood projection could also be created when a force acts upon a quantity of blood of approximately 0.10 ml or greater. For example, this occurs commonly at scenes where someone has stepped or stomped into a pool of blood, projecting the blood away from the blood pool.

D. GUNSHOT WOUNDS

1. Forward spatter

   a) Forward spatter is blood that travels in the same direction as the source of the energy or force which produced the spatter.
   b) Forward spatter varies in size depending upon the injury. The size could vary from .1 millimeter or smaller with some larger stains obvious. The smaller bloodstains do not travel as far as the larger bloodstains.

2. Back spatter

   a) Back spatter is blood that is directed back toward the source of the energy producing the blood drops.
   b) Back spatter often results from a gunshot entrance wound to a body. The unimpeded blood spatters back toward the weapon.

3. Draw-back effect

   a) The draw-back effect sucks blood into the muzzle of a firearm immediately after its discharge due to the partial vacuum created by contracting discharge gasses.
   b) The draw-back effect *can* be observed in contact gunshot wounds but the effect(s) of compensators, suppressors and silencing devices as well as any other intervening items may alter the outcome.

E. OTHER IMPACT SPATTER SOURCES

Baseball bats, other long handled implements such as crowbars; high speed machinery such as circular saws, band saws, drills, etc. – many possibilities

F. DETERMINING BLOODSHED ORIGIN

1. The location from which blood was shed can often be determined.

2. Point-of-convergence

   a) This is the two dimensional point establishing a bloodstain pattern's deposition direction. It is determined by tracing the long axis of well-defined bloodstains within a single pattern back to a point where the axes intersect or converge.
   b) This two dimensional point is used to help determine the three dimensional point of origin, or the approximate position of the victim at the time blood was shed.

3. Point-of-origin

   a) Measuring the length and width of blood drops and using trigonometry allows us to determine an approximate point of origin.
   b) The arc sin of $\frac{\text{the width of the bloodstain in mm}}{\text{the length of the bloodstain in mm}}$ = the impact angle
   c) Only experienced analysts trained in this technique should perform these measurements.
   d) Strings can be placed over blood drops along the axes of the stains at the calculated impact angles, and a resulting point of origin can be visualized in three dimensions.
   e) Error rates are a hotly debated topic, but 'error rate' for point of origin calculations can be thought of as an area about the size of a basketball.

G. CLOTHING

1. Suspects, victims, and bystanders will often become spattered with blood during blood shedding events. However the absence of blood on a person's clothing does not *by itself* indicate that he or she is not the offender or that he or she was not present when blood was shed.

   a) The clothing could be changed
   b) No spatter may strike the suspect if the victim's body or another barrier is between the suspect and the source of the blood shed
   c) The suspect may be nude during the offense, etc.

2. Each item of bloodstained clothing may help indicate where and how the victim was injured when the bloodstains were deposited on the garment.

H. SUMMARY

1. Often at crime scenes, the physical evidence contradicts eyewitness testimony. Physical evidence, including bloodstain evidence, is more reliable than evidence based *solely* upon witness memory.

2. To be presented accurately and usefully in court, bloodstain evidence must be recognized, documented, preserved, and correctly evaluated.

3. Bloodstain pattern analysis is a valuable tool to help explain blood-shedding events.

GLOSSARY

The following list of suggested terminology from the ***International Association of Bloodstain Pattern Analysts [IABPA]*** is offered as a simple reference.

ANGLE OF IMPACT - The acute angle formed between the direction of a blood drop and the plane of the surface it strikes

ARTERIAL SPURTING (OR GUSHING) PATTERN - Bloodstain pattern(s) resulting from blood exiting the body under pressure from a breached artery

BACK SPATTER - Blood directed back towards the source of energy or force that caused the spatter

BLOODSTAIN - Evidence that liquid blood has come into contact with a surface.

BUBBLE RINGS - Rings in blood that result when blood containing air bubbles dries and retains the bubble's circular configuration as a dried outline

CAST-OFF PATTERN - A bloodstain pattern created when blood is released or thrown from a blood-bearing object in motion

DIRECTION OF FLIGHT - The trajectory of a blood drop which can be established by its angle of impact and directionality angle

DIRECTIONALITY ANGLE - The angle between the long axis of a bloodstain and a predetermined line on the plane of the target surface which represents 0 degrees

DIRECTIONALITY - The directionality of a bloodstain or pattern which indicates the direction the blood was traveling when it impacted the target surface. Directionality of a blood drop's flight can usually be established from the geometric shape of its bloodstain

DRAW-BACK EFFECT - Blood in the barrel of a firearm that has been drawn backward into the muzzle

DRIP PATTERN - A bloodstain pattern which results from blood dripping into blood.

EXPIRATED BLOOD - Blood that is blown out of the nose, mouth, or a wound because of air pressure and/or airflow which is the propelling force

FLIGHT PATH - The path of the blood drop, as it moves though space, from the impact site to the target

FLOW PATTERN - A change in the shape and direction of a bloodstain due to the influence of gravity or movement of the object

FORWARD SPATTER - Blood which travels in the same direction as the source of energy or force which caused the spatter

IMPACT PATTERN - Bloodstain pattern caused when blood received a blow or force resulting in the random dispersion of smaller drops of blood

IMPACT SITE - That point where force encounters a source of blood

MISTING - Blood that has been reduced to a fine spray, as a result of the energy or force applied to it

PARENT DROP - A drop of blood from which a wave, cast-off, or satellite spatter originates

PASSIVE DROP (BLEEDING) - Bloodstain drop(s) created or formed by the force of gravity acting alone

PERIMETER STAIN - A bloodstain that consists of only its outer periphery, the central area having been removed by wiping or flaking after liquid blood has partially or completely dried

POINT (AREA) OF CONVERGENCE - The common point (area), on a two dimensional surface, over which the directionality of several blood drops can be retraced

POINT (AREA) OF ORIGIN - The common point (area) in three-dimensional space to which the trajectories of several blood drops can be retraced

PROJECTED BLOOD PATTERN - A bloodstain pattern, such as arterial spurting, that is produced by blood released under pressure as opposed to an impact

RICOCHET- The deflection of blood after impact with one target surface that results in staining of a second target surface

SATELLITE SPATTER - Small droplets of blood that are distributed around a drop or pool of blood as a result of the blood impacting the target surface

SPATTER- That blood which has been dispersed as a result of force applied to a source of blood. Patterns produced are often characteristic of the nature of the forces that created them

SPINE - The pointed or elongated stains which radiate away from the central area of a bloodstain

SWIPE PATTERN - The transfer of blood from a moving source onto an unstained surface – the direction of travel may be determined by the feathered edge of the pattern

TARGET - A surface upon which blood has been deposited

TRANSFER/CONTACT PATTERN - A bloodstain pattern created when a wet, bloody surface comes in contact with a second surface. A recognizable image of all or a portion of the original surface may be observed in the pattern

VOID - An absence of stains in an otherwise continuous bloodstain pattern

WAVE CAST-OFF - A small blood drop that originates from a parent drop of blood due to the wave-like action of the liquid in conjunction with striking a surface

WIPE PATTERN - A bloodstain pattern created when an object moves through an existing stain, removing and/or altering its appearance

Contact information:

Jon J. Nordby, Ph.D., D-ABMDI
Final Analysis Forensics, University Place WA
Email: finalanalysis@comcast.net
Web: www.finalanalysisforensics.com

