Introduction to Forensic Science

Bloodstain Pattern Analysis

I.   Introduction
A. The study of bloodstain patterns is another tool in the arsenal of forensic scientists that helps them determine what may have (or may not have) occurred at a crime scene where blood has been shed.
B. The analysis of bloodstain patterns may help to corroborate other evidence, reconstruct the event, identify and apprehend suspects, or clear falsely accused suspects.
C. The following information can often be obtained through the analysis of bloodstain patterns:
    1. Origin on the bloodstains
    2. Distance between impact areas of blood spatter and the origin of the blood spatter at the time of the bloodshed
    3. Object that may have produced the bloodstain patterns
    4. Positions of the victims, suspects, and objects while the blood was being shed
    5. Movement of the suspects, victims, and objects after the blood was shed
D. In order to become a skilled bloodstain pattern analyst, one must complete formal training, take part in experimentation, and gain experience through actual casework.

II.   History of Bloodstain Pattern Analysis
A. The earliest reference to testimony using blood spatter evidence was a trial in London conducted in 1514. Richard Hunne was found hanging in his jail cell in London. At first, the authorities believed Hunne had committed suicide. On closer inspection, it was found that a considerable amount of blood had been shed before he hung himself, leading the authorities to change his cause of death from suicide to homicide.

B. 1895 - Dr. Eduard Piotrowski, Institute for Forensic Medicine, Poland
Dr. Piotrowski's work on the origin, shape, direction, and distribution of bloodstains as a result of head wounds was the first of its kind, a thorough and highly controlled scientific study of bloodstain pattern analysis

C. 1939 - Dr. Victor Balthazard and associates presented a paper at the 22nd Congress of Forensic Medicine on research concerning blood spatter and pattern analysis.

D. During the 1930's, John Glaister, a Scottish pathologist categorized blood spatter into six distinct categories:
    1. Blood drops on horizontal surfaces

2. Blood splashes, which have flown through the air and are deposited on a surface that is at an angle
3. Pools of blood adjacent to the body, which may clearly indicate whether or not the body has been dragged
4. Blood spurts from major arteries or veins
5. Blood smears which result from movement of a bleeding person
6. Trails of blood, either when a body has been dragged or when the wounded person walks away dripping blood.

E. 1955 - Dr. Paul Kirk, UC Berkeley, testified via affidavit regarding Sam Shepard case. From the bloodstain evidence, Dr. Kirk was able to prove that the attacker who beat Dr. Shepherd's wife administered the blows with his/her left hand. Dr. Shepherd was right handed. This was the court's first acceptance of bloodstain evidence at trial.

F. 1971- After years of research and experimentation, Herbert Leon MacDonell, of the Laboratory of Forensic Science at Corning, NY, wrote the first modern book on bloodstain interpretation and analysis. His book is entitled "Flight Characteristics of Human Blood and Stain Patterns." A revised edition was published in 1997.

G. 1983 - International Association of Bloodstain Pattern Analysts (IABPA) was formed by MacDonell and his peers at the Advanced Bloodstain Institute. This organization has members all over the world. Their newsletter discusses current bloodstain topics and scheduled training events.

III.   Physical properties of blood
A. Blood is the fluid that circulates in the heart, arteries, capillaries, and veins of a humans and animals, carrying nourishment and oxygen to and bringing away waste products from all parts of the body
B. Blood's color comes from the presence of oxygenated hemoglobin that is present in red blood cells.
C. Blood, which is exposed to air through trauma, behaves according to the laws of fluid dynamics.
    1. Clotting and drying begin as soon as blood is exposed to air.
    2. Blood droplets form when small masses of blood separate from larger masses outside the body.
        a. Gravity or impact causes the separation.
D. Blood is a viscous fluid. The molecules in blood are held together by mutual attraction. Blood's viscosity, along with surface tension and gravity, help blood maintain its stability.

IV. **Methods of blood stain detection**
A. Naked eye
B. Luminol - the chemical, luminol is a valuable asset in the arsenal of tools available today to forensic technicians
    1. Luminol produces a bright blue luminescence even with only minute traces of blood present
    2. Luminol is only observable in darkness
C. To see how luminol works, visit the following url:
http://science.howstuffworks.com/luminol1.htm
D. In a recent issue of the Journal of Forensic Identification, Terry Waldoch reported the discovery of blood evidence in the murder of Deanna Seifert, which led to the conviction of the perpetrator. This evidence was discovered seventy-two days after the murder, in a parking lot that had received nearly eight inches of rain.

V. **Factors that influence the amount of spatter present**

A. Bloodstain pattern analysis is often an integral part of the reconstruction of crime scenes. When a well-known Cincinnati physician appeared to be the victim of a suicide, the blood spatter pattern discovered on his hand and couch told a different story. The types of bloodstains indicated how the blood was projected from the body.
    1. Type of injuries present
    2. The order in which the wounds were accomplished
    3. Whose blood is present (victim, perpetrator, other)
    4. The type of weapon that caused the injuries (knife, machete, 9 mm gun)
    5. The position of the victim when the injury was inflicted (lying in bed, running through the house, etc.
    6. Whether the victim was moved after the injury was imposed
    7. The distance the blood drops fell before hitting any surfaces where they were found

B. Surface textures' effect on bloodstain patterns
    1. Smooth surfaces reveal fewer spatters because there is less surface area to deflect the fluid.
    2. Fabric absorbs blood, hard plastic does not absorb blood.
    3. Many outdoor surfaces are water-resistant, leaving no blood evidence.

VI. Factors which indicate how blood was projected onto surfaces
A. The size and shape of blood drops indicate the velocity, direction, and distance from the point of origin
B. Generally speaking, the higher the energy of the impact, the smaller the drops
C. Free falling blood has a low velocity, leaving large drops
D. Greater distance = greater diameter

1. On smooth cardboard, the diameter of bloodstains increases as the distance between the source of the blood and the surface upon which it falls increases.

E. Blood trails come in several forms.
    1. Blood smears - indicate a body that has been drug
    2. Blood droplets - indicate a body that has been carried or the victim walked away while bleeding

F. Bloodstain patterns can be traced back to their convergence point by considering these factors:
    1. The surface upon which it is found
        a. The harder the surface, the less spatter.
    2. The angle that the blood drop hit the surface
    3. The distance it traveled

VII. Important terminology

A. Point of origin - the place from which the blood in a bloodstain originated

B. Point of convergence - a common point to which individual bloodstains can be traced back to

C. Angle of impact - the acute or internal angle formed between the direction of a blood drop and the plane of the surface it strikes

D. Surface tension - the tendency of the surface of a liquid to contract to possess the smallest area possible

E. Gravitational force must be greater than the surface tension before a blood drop will fall.

F. Terminal velocity - the maximum speed that a drop can reach in air (the velocity of a drop of blood will continue to increase until the force of air resistance opposing the falling drop is equal to the downward gravitational pull)
MacDonell determined that the rate of a .05 ml drop of blood would have a terminal velocity of 25. 1 foot per second

VIII. How to determine the point of origin

A. First determine the angle of impact using several bloodstains
    1. Angle of impact = arc sin W/L
    2. For example, use a bloodstain with the following measurements:
        a. Width = 5 mm
        b. Length = 10 mm
        c. L/W = 10/5 = 2
        d. Refer to chart - a bloodstain with a L/W ratio of 2 has an angle of impact of 30'.
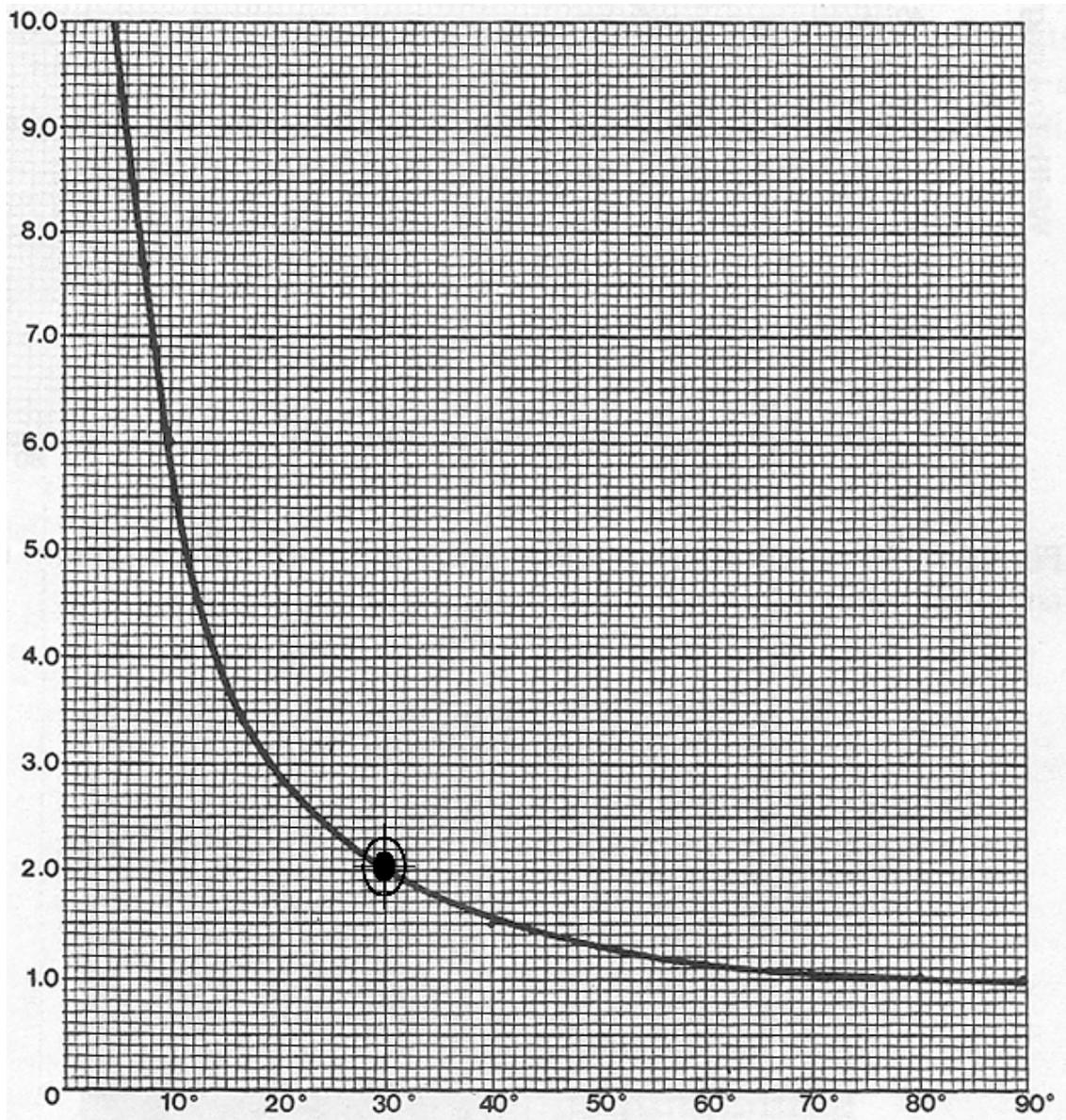
B. Then determine the point of convergence through the long axes of the bloodstains.

C. Measure the distance from the base of the individual bloodstains to the point of convergence.

D. Calculate the point of origin (or elevation in space) which is the length of the z-axis. Use this equation:

> Point of origin (Z) = the tangent of the angle of impact multiplied by the distance of stain from point of convergence (Y)

E. When measuring bloodstain patterns in relation to a room or space, measure the horizontal distance in feet and the vertical height in inches.

IX. Bloodstain patterns

A. High velocity spatter - a bloodstain pattern caused by a high velocity force such as by gunshot or high speed machinery, which results in a mist-like distribution

B. Medium velocity spatter - a bloodstain pattern often caused by a medium velocity force such as a beating, normally creating blood spots from 1-3 millimeters

C. Low velocity spatter - a bloodstain pattern caused by a low velocity force, often resulting in bloodstains of a larger size than medium or high velocity forces. Low velocity bloodstain patterns frequently show the greatest variety in size and shape. Individual blood drops falling from the source of blood are also considered low velocity blood spatter.

D. Cast off patterns - bloodstain patterns that are created when blood is released from an object or person in motion. Castoff patterns may reveal the positioning and the possible size of the assailant. Castoff drops that are thrown off of a swinging instrument can illustrate the position of the attacker when swinging a knife, or club.

E. Swipe patterns - bloodstain patterns that are created when blood is transferred to a surface that hadn't been contaminated with blood previously. One edge is often feathered and might indicate the direction of travel.

F. Wipe patterns - bloodstain patterns that are created when an object moves through a bloodstain and alters its original appearance

X. Collection and preservation techniques

A. Photograph the bloodstains
- 1. Always take at least 3 photographs
  - a. Orientation to the crime scene, no scales, include your measurement start point in the photograph
  - b. Close up of just the bloodstain pattern
  - c. Another set with the scales

B. Precautions to be taken by crime scene personnel to prevent AIDS and Hepatitis infections
- 1. Consider all body fluids infectious whether wet or dry
- 2. Place all sharp objects, (knives, razor blades, syringes, etc.) in puncture resistant containers
- 3. Wash hands with soap and water after every assignment.
- 4. Bandage any wounds you might have so that they are completely closed off from any infectious fluids you might come into contact with.
- 5. Wear latex gloves, masks, and eye protectors when handling body fluid evidence.
- 6. Avoid eating, smoking, and drinking in any situations where you may transfer infectious agents from one person to another.
- 7. Surfaces that have become contaminated with blood should be washed with a 1:10 solution of bleach and water.

XI. Documentation of bloodstain pattern evidence
A. In the case of bloodstain pattern evidence, photographic documentation of the crime scene is of utmost importance. Investigators responding to death investigations often do not appreciate the value of bloodstain pattern evidence.
B. Photographic documentation must include photographs of the victim, the crime scene, the physical evidence, and if possible, the assailant.
C. The photographs taken of these items and people should be taken using a 35 - 50 mm lens using a flash and color film. Close-ups should also be taken using a macro lens. A measuring device scaled in millimeters and inches should clearly be visible in each and every photograph.
D. 8 x 10 color enlargements of the crime scene photographs should be used in the courtroom as evidence.
E. High velocity spatter is often very minute and must be photographed properly to be of the greatest possible use as evidence.

XII. Use of bloodstain evidence at trial
A. Sam Sheppard was originally found guilty in the brutal beating death of his wife Marilyn. He served ten years in the Ohio State Penitentiary. After Sheppard was convicted, Dr. Paul Kirk found blood evidence in his home, pointing to another perpetrator. A blood spot was found in the house that was neither Sam's nor Marilyn's. Furthermore, the bloodstain evidence indicated that a person who was left-handed had perpetrated the crime. Sam Shepherd was right-handed. This evidence led the second jury to find Sheppard not guilty twelve years later.

B. O.J. Simpson case - Quite a bit of bloodstain evidence was gathered in the double murder of Nicole Brown Simpson and Ron Goldman. When several drops of blood found at the crime scene failed to match either victim, O.J. Simpson's blood was compared to the blood found at the scene. The tests showed that only one person in 57 billion could produce an equivalent match. These blood drops were found next to footprints made by a rare, expensive shoe type, found to be the same size as O.J. Simpson's. Simpson escaped conviction due to the reasonable doubt of the jurors who appeared to have believed that the blood evidence was planted by the LAPD.

XIII. Alternative methods of bloodstain pattern analysis
A. Crime scene investigators often use strings at the crime scene to reconstruct the blood flight path, especially when there is quite a bit of blood spatter
B. The Crime Zone is a program, which allows one to quickly and accurately create three-dimensional models of crime scenes, which can later be used in the courtroom to explain the importance of the data.
C. 3D Eyewitness Crime is another Windows based visualization software useful in recreating crime scenes. It also allows you to create a 3D Movie providing a walk through of the crime scene.