Bloodstain Pattern Analysis
What Is Blood?

- A non-Newtonian viscoelastic fluid (Wonder, p. 8).
- An adhesive substance.
- “A vital, complex biological fluid, containing red blood cells, which is present in vertebrates and may be shed during accidental, intentional, and/or criminal acts (Wonder, p. 11).”
- A substance with a distinct color, texture, hue, physicalness, and behavior.
What is a Bloodstain Pattern?

• A bloodstain pattern is a physical, geometric image created by blood contacting a surface, or by a surface contacting blood.

• The geometric images of interest are primarily those created once blood leaves the body.
Bloodstain Pattern Analysis

- Bloodstain pattern analysis is the interpretation of information presented by bloodstain patterns. It involves pattern recognition and interpretation. The interpretation of the information is aimed at supporting inferences relating to actions that took place during an event involving blood. Bloodstain evidence at a scene can be very useful in helping to reconstruct actions that took place at a scene, corroborating actor’s statements, and identifying actors. The evidence is physical evidence. All information offered as originating with bloodstain interpretation must be supported with careful documentation and accurate analysis.
Analysis of Bloodstain Patterns

- Analysis involves an understanding of the physical properties of blood: surface tension, viscosity, internal cohesion, drop formation, fluid dynamics, specific gravity, in flight behavior.
- Analysis involves an understanding of physical actions of blood prior to, during, and after contact with a surface: oscillations, breakup, elasticity, geometric shape, configuration mechanics.
- Analysis involves image recognition, physical and mathematical interpretation of patterns, corroborative research and logical inference processes.
Probable Information From Bloodstains

- Direction
- Angle of Impact
- Origin
- Applicable Forces
- Trajectories of Forces
- Object Identification
- Number of Blood Initiating or Altering Events
- Actors Positions
- Sequence of Events
- Left Handed/Right Handed
- Clothed/Unclothed
- “Psychoscene” Presentation
- Non-linear Behavior
Physical Properties Affecting Bloodstain Patterns.

- Origination Surface Construction
- Impact Surface Construction
- Temperature
- Humidity
- Capillary Action
- Time
- Adhesiveness
- Internal Cohesion (Wonder, 2001).

- Actor Movement
- Contamination
- Distance
- Extraneous Energy
- Origination Initial Force
- Volume
- Scene Integrity
- Surface Tension (Bevel and Gardner, 2002).
Impact Surface Considerations

- Course surfaces cause irregularities in patterns.
- Blood may break up on impact, and may follow the contour of a surface (Bevel & Gardner, 2002).
- Impact angles and directionality become less reliable as a surface become more porous (inverse relationship).
Some General Characteristics of Moving Blood

- In a free fall form, a drop will move in an oscillating spherical configuration –*not in a teardrop shape* (Bevel and Gardner, 2002).
- Age, sex, race, nor alcohol blood levels seem to affect the patterns produced (MacDonell, 1993).
- The preceding do affect blood patterns. (Wonder, 2001).
- Terminal velocity is generally reached 6’-8’.

- In a free falling form, the volume of a drop will be about .03 ml -.05 ml/ diameter about 3mm –5mm. Collision and force produce smaller sizes.
- Larger drops tend to project further than smaller drops.
- After about 6’, increased distance fallen does not affect stain size.
- Hematocrit, internal cohesions, and surface tension affect blood drop formation. (Wonder, 2001).
Bloodstain Pattern Recognition – Pattern Types

- Passive Patterns: flow, pool, saturation, drip/drop, volume.
- Projected Patterns: instrumental, expired, arterial spurt/gush.
- Impact Patterns: blood splashes, object splashes, drops, drips, trails, object impacts.
- Impression Patterns: transfer, contact, swipe, wipe, secondary.
- Artifactual Patterns: voids, fly spots, insect/bug trails, bubbles, blood (dried, skeletonized, separated).
Passive Patterns

- Those patterns which generally result from the free flow of blood.
- Passive Flow Pattern – when blood flows freely.
- Passive Saturation Pattern – when blood flows to saturate an area.
Passive Patterns (Cont.)

- Passive Saturation – in cloth there may be secondary patterns from the cloth folded on itself. In some literature this is called a secondary transfer pattern.
- Passive Pool Pattern – when blood flows freely into a pool.
- Notice: trail, drip.

trail

drip
Passive Patterns (cont.)

Free flow around a surface notice pattern from lap and buttocks.

Notice void areas in this passive pattern.
Projected Patterns

- Those patterns resulting from blood sent with a degree of energy, other than gravity, from an origin to a surface. Blood is shot, flung, or hurled at a surface, as examples.

- Arterial Spurt/Gush Pattern - blood which leaves the body under pressure: breached artery.

  *Note: rhythmic pattern.

Arterial Spurt and Free Flow
Projected Patterns (cont.)

- Expirated Pattern – blood projected from the mouth, nose, or a gaping wound. Often an expired pattern is found with saturation and pool patterns. Notice the expired pattern on the side of the chair, and the saturation pattern on the bed corner. The victim had a throat wound.
Projected Patterns (cont.)

- Expirated patterns have the appearance of medium to low velocity blood spatter.
- Expirated patterns may also be found with arterial spurt patterns, and cast-off patterns.
Projected Patterns (cont.)

- Instrumental Projected Patterns – These are patterns, that for lack of a better name, are caused, in part, by an instrument that is part of the origination of the blood spatter. Some examples of instruments are: knife, firearm, board, swinging hand, kicking foot, bat. The blood is projected from the instrument.

High Energy - Shotgun
Projected Patterns (cont.)

- Instrumental Projected Patterns:
  - High Energy (velocity): 100’/sec or more, firearms, airplane propeller, power equipment.
  - Often has a misting effect appearance, and spatters less than 1mm in diameter.
  - In the photos note the mass and misting areas.

suicide

test pattern
Projected Patterns (cont.)

- Instrumental Projected Patterns:
  - Medium velocity: 25'/sec or more, swinging knife, bat, kicking foot, swinging hand, expired, arterial.
  - No predominance of stains with a diameter less than 1mm.
  - A trail may present in a pattern from a swinging instrument (+1 rule).

Medium energy(velocity) with transfer pattern.
Projected Patterns (cont.)

- Instrumental Projected Patterns:
  - Low Velocity: free falling velocity, blood dropping from a cut finger, bleeding nose, other wounds, or a near immobile instrument.
  - Some literature designates as drop patterns.
  - Bleedings, walking subjects may leave a low velocity trail.

drops at homicide

dropped blood
Projected Blood (cont.)

• Size difference in free falling drips can be due to: distance, surface from which blood is dripping.
• Blood dripping into blood: notice the smaller “satellite” stains - compare these with the “radial” stains from a volume drop, or an object impacting a pool of blood.
Projected Blood (cont.)

- Instrumental Projected Patterns:
  - Cast off: a special term reserved for spatters cast from an instrument.
  
  - Cast off patterns seem to particularly apply to sharp force and blunt trauma instruments.
  
  - Wave cast off: term for a pattern resulting from a cast off from a cast off. *caution*.

cast off from fleeing suspect
Projected Patterns (cont.)

- **Instrumental Projected Patterns:**
  Cast off: A moving instrument may produce a pattern in which the blood spatter creates a “trail”. The “trail may reproduce several times. A very general rule is that the number of blows to a victim is one more than the number of “trails”. *caution*.

Cast off “trail” on back side of pajama bottom – notice multiple “trail” or “arc” phenomena.
Projected Patterns (Cont.)

- Projected blood forming an arc that was from an assault with a hammer.
- Notice the mixture of patterns.
Projected Patterns (cont.)

- Additional arc patterns, consistent with being struck with an object, are evident in the photo.
- Notice the mix with the contact pattern.
- The victim reported being repeatedly struck while covering up and trying to get away.
- Are the patterns consistent with the story?
Projected Patterns (cont.)

- **Instrumental Projected Patterns:**

  Backspatter: generally applies to firearm phenomena in which the blood from the wound is also forced backwards onto the subject of a surface.

  - Hands are common backspatter surfaces.
  - Very easy to confuse with expired blood.

  backspatter from gunshot wound.
Impact Patterns

• Impact patterns: produced when blood splashes.
• May be produced from blood falling into blood, or an object impacting blood.
• These patterns are called splash patterns in some literature.
• Characteristics: “spiny” edges, circumferential surrounding stains.

Volume pattern: a volume of blood impacts surface, and falls into itself. Notice the radiating patterns.
Impact Patterns (cont.)

• **Impact Patterns:**
  
  **Drip:** when blood drips into blood.
  
  **Object splash:** when an object impacts a volume of blood.

  *Caution: carefully try to establish any continuity.*
Blood drips into blood and splashes onto the chair leg.

An assault victim leaves a blood trail - notice the dripping, splashing, and adjacent bloodstains.
Impression Patterns

- Patterns created: surface contacts a surface leaving an impression.
  - **transfer**: bloody surface to secondary surface (bloody hand to wall).
  - **contact**: object surface contacts blood (shoe print).
  - **swipe**: bloody object moves across surface (hair).
  - **wipe**: object moves through blood (hand through drop).

Transfer: notice outline of parallel liner line pattern. This is a pattern from a arm touching the table.
Notice the swipe patterns on the wall, and by the foot. Notice the wipe through the blood with the feathering of the stain, and the swipe to the left.
Impression Pattern (cont.)

Wipe: Notice the remaining skeleton of the original stain. The “feathering” out of the swipe indicates direction.

Wipe: A little more difficult to tell. It almost looks like a swipe. This was made with a brush.
Impression Patterns (cont.)

A transfer pattern from the shotgun to the bed sheet.

Knife blade and handle transfers.
Impression Patterns (cont.)

A contact pattern from a shoe at the scene of an assault.

Knife transfer pattern from a homicide scene. Notice the handle pattern in the far left.
Impression Patterns (cont.)

Footprint - Homicide

Hammer Impression - Homicide
Impression Patterns (cont.)

A transfer swipe pattern from The scene of an assault. notice the mixture of the transfer, free flow, and cast off patterns.

A very subtle swipe mark in carpet at the scene of a homicide. The marks start at upper center and arc downward.
Impression Patterns (cont.)

- Impression patterns may be enhanced by the use of bloodstain dyes (Amido Black, Coomassie Blue), Luminol, Alternate Light Source, or Fluorescein.
- Since identity can often be established by DNA, a sample of any pattern should be taken prior to enhancement.
- Would Luminol have aided the carpet pattern in the previous slide?

Luminol enhancement
Artifactual Patterns

• These are patterns that are extraneous to direct human blood loss.
  Fly artifacts: patterns created by flies.
  Bugs/insects: created by interaction with bugs.
  Blood: blood that dries, bubbles, or separates.

Dried blood drop: skeletonized.

Dried Blood: notice from outer edges in, & flaking away in right stain.
Artifactual Patterns (cont.)

Fly spots on the kitchen wall above the head of double homicide victims. Both victims received handgun head wounds.

Fly spots on a window shade at a death scene. Notice the similarity to low-medium velocity.
Artifactual Patterns (cont.)

Air bubbles in blood on the blade of a knife.

Fly spots on a window at a homicide scene. This is not a picture of a sperm cell.
Artifactual Pattern (cont.)

- Blood has an adhesive quality.
- It may create a bonding phenomena between two surface. When separated one can observe the “alligatoring” effect.
- If a measurement is made after “bonding” it should be considered smaller than the actual object structure.
Artifactual Pattern (cont.)

It is not what it seems at first? This is a volume, free flow, drip and drop, and arterial spurt pattern. It is not a high velocity pattern. It was created, in part, by wind whipping around the edge of the building.
Blood On Clothing

- **Impact angle calculations do not apply.**
- Directionality determinations are possible.
- Contact, transfer, & passive actions usually on one side.
- Projected related actions, volume actions usually on both sides.
- Always corroborate before making final inference.
- **The most difficult of all interpretations?**
Angles of Impact

• Angles of impact can be determined by dividing the width of a bloodstain pattern by the length of the pattern. The value of this division is the sin (sine) of the angle of impact (AOI). The arcsin (arcsine) (arc\(^{-1}\)) is the value in degrees that corresponds to the sin. \(\text{AOI} = \sin^{-1} \frac{w}{l}\).

• The angle of impact is dependent upon the accuracy of measurement (the literature indicates an error rate of +/- 10%).

• The angle of impact is a generalization.
Angle Of Impact (cont.)

- Blood which impacts a surface at a 90 degree angle will be nearly round in shape.
- As the blood impacts at angles decreasing from 90 degrees the pattern will become more elongated and elliptical.
- The angle of impact is that between the surface and angle line.
Angle of Impact (AOI) Procedures

\[ \frac{w}{l} = \sin = \frac{8}{49} = 0.163, \quad \arcsin 0.163 = 9^\circ \text{ degrees}. \]
Direction Of Travel

- Direction of travel refers to the direction in which the blood spatter is moving from its origin to its destination.
- It can be determined from spatters from the “tail”.
- In free flow and swipes and wipes it can be determined by spatial relationships and feathering of the pattern.

A line drawn through the center of the longest aspect (axis) of the stain, and in the direction of the “tail” points in the direction of travel.
Origin

- Origin refers to the place from which the blood came in space. It is a physical location.
- For multiple stains, the origin can be determined in a two-dimensional aspect by drawing lines through the center of the stains in the direction of travel and in the corresponding reverse direction, and observing the point (area) of convergence.
- **The origin corresponds to the opposite direction of the direction of travel.**

Lines drawn through bloodstain patterns to determine convergence.
A three dimensional point of origin can be determined by several methods.

- stringing: placing strings along the direction of travel and the angle line of the angle of impact.
- computer models.
- mathematical: using right angle triangle procedures.

Mathematical charting in preparation for determining three dimensional origin. If one angle and one side are known, the others can be determined.
Visual Indications of Origin

• Some analysts prefer to use strings to visualize origin.
• A quick generalization of probable origin is to sue colored markers that are aligned on the axis of the direction of travel.
Determining Origin Mathematically.

Angle of Impact = 10 degrees.

Right Triangle: \( C^2 = A^2 + B^2 \); \( \tan \theta = \frac{B}{A} \), \( B = \tan \theta \times A \)

\( A = \) Distance from bloodstain impact to area of convergence. \( B = \) Distance from impacted surface to origin. If \( A = 20\text{cm} \), then \( B = \tan 10\text{ degrees} \times 20\text{cm} = 0.176 \times 20 \text{ cm} = 3.5 \text{ cm} \).
Arrow through center points to direction of wipe.

Photo shows the direction of travel is approximately 59 degrees. (or 239).

Arrow and notation indicate zero to right and north.
Blood For Purposes of Reconstruction

- Identity Locates Actors
- Bloodstain Patterns Locate Actions
- Actors + Actions Suggest Scenario
- Scenario May Suggest Motive
- Motive May Suggest The Crime
Blood As Evidence

- Photograph - if applicable.
- Measure – if applicable.
- Contamination control – DNA has changed the requirements.
- Use clean instruments or clean instruments.
- Dry and/or refrigerate for storage.
- Controls are essential.
- Document patterns

- Purple top tubes – DNA.
- Red top tubes – toxicology.
- Dry blood is best.
- String, patch, swab – wet sample
- Chain of Custody is essential.
- Presumptive tests are helpful – Hemastix, Fluorescein.
- Describe appearance.
Blood For Purposes of Identity

- Serology - standard analysis
- DNA – now becoming most used for identity purposes.
- Toxicology – alcohol, drug analysis
- Pathology – disease
- Paternity - parentage
- Anthropology and Archaeology - historicity
Identifying and Enhancing Blood

- Hemastix – presumptive test, least sensitive.
- Many Tests Between These Two – Phenothalein, Luminol.
- Fluorescein – presumptive test, most sensitive.
- Physicality – does it look like blood, smell like blood, act like blood, and should it be blood.
- Positive identification is only by laboratory analysis.
- *False positives are possible with all tests and enhancements.*
- Luminol – strong reaction, short term, carcinogenic.
- Fluorescein – strong reaction, very sensitive, can be used in daylight, requires ALS.
- Amido Black – heavy staining, carcinogenic.
- LeucoCrystal Violet – easy to mix, strong staining, carcinogenic.
- Hungarian Red – requires ALS, white lifters.
- Coomassie Blue – good stain, easy to use.
Bloodstain Pattern Analysis: Summary and Conclusion

- Bloodstain pattern analysis is a scientific application with limitations. One cannot extrapolate beyond the best possible explanation.
- In a consilience orientation to crime scene investigation, bloodstain pattern analysis is a component part of the total investigation, and subject to the protocols, procedures, rules, and laws attendant to all investigations.
- Are you an expert witness?
Safety Precautions With Blood

- Personal Protection – Respirator, Gloves, Protective Clothing.
- Package For Preservation.
- Try Not To Scrape or Agitate
- Contamination Control – Critical.
- Exemplars and controls – Critical.
- Chain of Custody – Critical.
References


References


