



**PROCEDURE FOR THE  
ANALYSIS OF BLOODSTAIN  
PATTERN EVIDENCE**



**DNA ANALYSIS UNIT I  
FBI LABORATORY**



# Procedure for the Analysis of Bloodstain Pattern Evidence

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# Procedure for the Analysis of Bloodstain Pattern Evidence

## SCOPE

This procedure applies to the evaluation of the physical characteristics of bloodstains and the patterns in which they are found. Such bloodstain pattern analysis (BPA) evaluations may be conducted to determine what action(s) or sequence of actions could have created the bloodstains and/or patterns observed.

## BACKGROUND

The general role of BPA in a criminal investigation is to assist in the reconstruction of those events of an alleged incident that could have created the stains and stain patterns present at a crime scene or on items of physical evidence recovered from that scene. The utility of individual bloodstains and bloodstain patterns lies in their retention of information descriptive of the events that resulted in their deposition at the positions they are observed. The physical nature of bloodstains and the patterns in which they are arranged are the static consequences of dynamic events that cause blood to be removed from objects or dispersed into droplets and subsequently deposited as stains on intermediate target surfaces. The sizes of the individual stains composing a pattern, the shapes of these stains, as well as their distribution relative to one another, can be utilized by the BPA Examiner (BPAE) for the purposes of determining how a particular stain or pattern may have been produced.

## EQUIPMENT/MATERIALS/REAGENTS

Scientific Calculator

Magnifying Glass (Ultra Loupe, Doje's Inc. or equivalent)

Ruler

Tape Measure

Protractor

Protrusion Rods

Ring Stand

String

Tripod

## PROCEDURE

Upon receipt of evidence items for a BPA examination, a BPAE will be assigned by the Unit Chief of the DNA Analysis Unit I (DNAU I), or by his/her designee<sup>1</sup>. The BPAE may need to collect investigative information prior to the examination of the submitted items or deployment of a BPA team to discern if the question(s) being asked by the contributor can be answered. The types of information that may be needed prior to examination or deployment include, but are not limited to:

- Crime scene reports
- Autopsy reports
- Hospital records
- Statements made by victim(s), suspect(s), and/or witness(es)
- Photographs
- Crime scene sketches/diagrams
- Videotapes
- Laboratory reports

After assessment of the available case information by the BPAE, in consultation with the BPA Program Manager, or his/her designee, a decision will be made as to whether a BPA examination can be conducted.

### 1 Analysis of Evidence <sup>[REFERENCES 1 - 5]</sup>

Following receipt and/or collection of BPA evidence, the BPAE will review the submitted case documentation and evidence. As needed, the BPAE may contact the submitting agency and discuss the nature of the crime scene and the details of the incident. It will be at the discretion of the assigned BPAE as to the number and types of items that will be examined in a BPA case. Any evidence submitted for examination will be documented by one or more of the following procedures (Sections 1.1 - 1.3). All information generated during this process will be included in the case notes. At a minimum, the following information must be recorded when documenting BPA evidence:

- Case Identification Number
- Date
- Sequential identifier (e.g., Q1, Q2, K1, K2, etc.)
- BPAE identifier

#### 1.1 Photography

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<sup>1</sup> In some circumstances, a BPA response team may be requested. In these cases, the composition of the team and the decision to respond will be made by Laboratory Division management and the DNAUI unit chief or by his/her designee.

- 1.1.1 Individual items of evidence may be submitted to the Special Photographic Unit (SPU) for image processing. Photographs may also be taken by a member of the BPA examination team. The type of camera to be used (e.g., digital, 35 mm, instamatic, etc.) is at the discretion of the BPAE and may be made in consultation with SPU if necessary. Photographs should capture overall, mid-range, and/or close-up views of the evidence
- 1.1.2 As appropriate, a ruler or other familiar object, such as a coin, may be used as a reference in the photography process for size comparison.
- 1.1.3 Transfer of BPA evidence will be recorded following the procedures provided in the LD and DNAU I *Quality Assurance Manual*.

## 1.2 Diagrams/Sketches

Diagrams or sketches may be prepared by the BPAE or in consultation with other designee(s) [i.e., SDU, Investigative and Prosecutive Graphic Unit (IPGU), Structural Design Unit (SDU), etc.] to document the location, appearance, dimensions and the distance a pattern is from a point of reference. Diagrams or sketches used in BPA may be made in pencil or ink. The need to produce such drawings to scale will be based on the judgement of the BPAE.

## 1.3 Narrative Description

- 1.3.1 Narrative descriptions may be prepared to record the appearance and patterning of the bloodstains and must include sufficient detail within the narrative so that they could serve together with the sketch/diagram(s) to supplement and/or replace inadequate photographs. The narrative must be a description of the item as it was upon receipt and describe in detail the bloodstain patterns present. The narrative may include any measurements deemed necessary by the BPAE.
- 1.3.2 If bloodstains and/or bloodstain patterns have been identified by letters/numbers, the narrative must also reflect these identifiers. The narrative must describe the types of stains and/or patterns present (e.g., flow patterns, impact stains, contact/transfer stains, etc.), the details with regard to their size, shape, number, distribution, directionality, and location. The narrative description of the stains and/or patterns may be supplemented with sketches, diagrams, and/or photographs for positioning of the described patterns.

## 2 **Pattern Identification** [REFERENCES 1 - 3, 6-10]

When examining bloodstains, the BPAE must attempt to identify any bloodstain

pattern(s) present and classify them based on their physical characteristics. Once classified, a particular type of bloodstain pattern should be evaluated for the presence of any additional information the particular pattern type may display. All observations must be recorded in the case notes.

## 2.1 Contact/Transfer Patterns

2.1.1 **Contact/Transfer patterns** are created when a wet, bloody surface comes into contact with a second surface. A recognizable image of all, or a portion of, the original surface may be observed in the pattern.

2.1.2 **Contact/Transfer patterns** are generally indistinct stains that can be of virtually any size or shape. The physical appearance of such stains is generally mottled with numerous variations in their color and/or density. The shape of a **contact/transfer pattern** may retain some of the physical characteristics of the object that created it. In this way, the shape of a **contact/transfer pattern** may suggest the object that created it through the recognizable patent image.

### 2.1.3 Direction of Motion

- a. The direction of motion of a **contact/transfer pattern** may be determined from the general density distribution of the stain. Generally, a **contact/transfer pattern** is heaviest in that portion of the stain deposited first, and its density decreases as blood is removed from the object.
- b. Feathered margins may be created as an object gradually comes into or loses contact with a target surface. Generally, feathering displays a gradual decrease in density in the direction of an object's movement. As a result, the trailing edge of a **contact/transfer pattern** may display lightened staining with respect to the leading edge.
- c. The presence of distinct front boundaries deposited along the margins of a **contact/transfer pattern** may allow a direction of movement to be determined. These front boundaries are the result of blood that collects along the leading edge of an object. Because these front boundaries are left where an object loses contact with a surface, they are most numerous in that portion of the stain deposited later.

- d. On fabric, it may be possible to determine the direction of movement based on the relative regularity of a pattern's margins. As a bloody surface moves across relatively loose fabric such as clothing or upholstery, the material may be bunched into one or more folds as the bloody object moves across the material. As a result, a **contact/transfer pattern** may produce a leading margin that is relatively gradual. The subsequent trailing margin created by this action may be more abrupt and linear as the bloody object moves over and off of a fold.

#### 2.1.4 Repetition

- a. **Contact/transfer patterns** deposited by a rolled object, such as a baseball bat, or other repetitive action (i.e., walking, etc.) may result in a repetitive series of stains that can be used to estimate the circumference of the object or stride length (i.e., walking versus running, etc.). If possible, make a measurement from a point on one stain of the series to the same approximate point on an adjacent stain. This distance approximates the circumference of the object. If possible, additional measurements should be made between other consecutive stains to verify this estimate.
- b. Repetitive **contact/transfer patterns** produced by the same object, such as a shoe-print trail, usually become less distinct as blood is removed from the object. However, this relationship may not be observed should the source be actively bleeding.

#### 2.1.5 Force

**Contact/transfer patterns** produced by a forceful interaction between an object and a receiving surface may result in spines that radiate from the pattern. These spines are the result of the forceful compression and subsequent ejection of blood present on the object and/or surface at relatively acute angles from between the object and the surface.

### 2.2 Passive Bloodstain Patterns<sup>[REFERENCES 10 - 15]</sup>

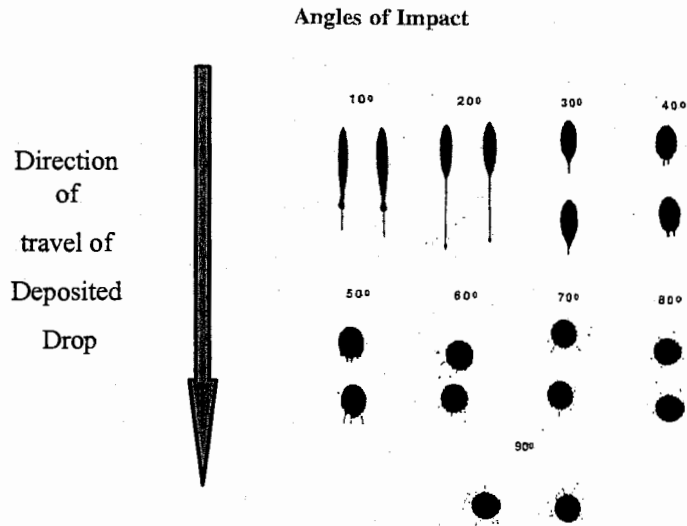
#### 2.2.1 Passive Drop Stain

- a. The **size** of an individual stain may, under special circumstances, be of value for the determination of the height from which its source drop fell, but only in situations when ancillary information



concerning the source drop is available. In the absence of such information, approximation of distance of fall determinations must not be attempted. [REFERENCE 16]

- b. The **size** of an individual bloodstain does not generally provide sufficient information to determine the characteristics of its surface of origin (i.e., hand, knife, hammer, etc.). In the absence of detailed ancillary information, surface of origin determinations must not be attempted.
- c. Care must be taken in any attempt to **size** individual bloodstains due to the effects that the receiving surface may have on the blood drop. Generally, the more textured a receiving surface the greater the disruption of the drop as it deposits on the surface. Such disruption can result in the creation of secondary satellite droplets that effectively reduce the total original volume of the parent drop. This reduction in total parent drop volume may then reduce the overall **size** of the resultant bloodstain thus making the measured stain **size** unproportional to its original volume.
- d. Porous surfaces, such as fabric, carpet, etc., may disrupt as well as absorb and/or wick blood away from the surface. Such absorptive and/or wicking actions may also reduce the overall **size** of a bloodstain thus making it difficult to relate the **size** of a stain to the volume of a drop.
- e. The **shape** of an individual bloodstain can provide information with respect to the angle at which a drop struck the surface. A blood drop that strikes a nonporous surface that is perpendicular (i.e.,  $90^\circ$ ) to its flight path will result in a circular stain. Such a stain will have equal width and length dimensions.
- f. Blood drops that strike a surface at more acute angles, that is, angles approaching  $0^\circ$ , or parallel to a surface, result in bloodstains that are progressively more elliptical in **shape** (Figure 1). The relationship between a bloodstain's width and length can be related to the angle of impact of the drop that created it through the trigonometric sine function (Section 7.1).



**Figure 1: Angles of Impact**

- g. The long axis of an elliptical bloodstain captures the plane through space that the blood drop was traveling at the time it was deposited. For many stains, particularly those deposited on non-porous surfaces, it may be possible to determine the direction a drop was moving from by a comparison of the edge characteristics in the two (2) extreme margins of the stain. That distal margin that displays lesser disruption with respect to its opposing margin was deposited first. The margin that displays the greater disruption was deposited second. In this way, a bloodstain can be said to have a directionality that tracks along the path of its long axis and in the direction that encounters its edge of lesser disruption first and edge of greater disruption next (Figure 1).
- h. Care must be taken when evaluating the **shape** of an individual bloodstain due to the effects that the target surface may have on the blood drop. Generally, the more textured a target surface the greater the disruption of the parent drop. Such disruption can result in the creation of secondary satellite droplets that display irregularities in the edge characteristics of the resultant bloodstain.
- i. Porous surfaces such as fabric, carpeting, etc. may nonuniformly absorb and/or wick blood away from the surface, distorting the **shape** of the bloodstain. Collectively, these irregularities and

distortions of individual bloodstains may alter the **shape** of the stain and render it unsuitable for the possible evaluation of its directionality [Section 2.2.1 (g)] and/or impact angle (Section 7.1).

### 2.2.2 Drip Patterns

- a. **Drip patterns** result from blood dripping into blood.
- b. **Drip patterns** generally display satellite staining which results from the deposition of small droplets that are ejected from the blood pool upon its being struck by a falling drop. Because these ejected blood droplets generally follow arching trajectories, they strike the surface at or near 90° and result in circular to near-circular stains. Additionally, because they are generally slow moving, the satellite stains surrounding the central pool of a **drip pattern** often display an observable thickness because their droplets lack the energy necessary to fully spread themselves over the target surface upon striking it.
- c. The satellite stains in the lateral margins of a **drip pattern** on a vertical surface often display evidence of gravity effects. Such satellite stains display directionality toward the horizontal surface because the droplets deposited were on the downward flight path of their travel arch. Also, the size of the satellite stains on a vertical surface will generally decrease as the distance from the blood pool that resulted in the **drip pattern** increases.

### 2.2.3 Flow Patterns

- a. **Flow patterns** are a change in the shape and direction of a bloodstain due to the influence of gravity or movement of the surface and are generally observed in circumstances where a volume of liquid blood moves freely along a downward path.
- b. **Flow patterns** may also display one or more long, narrow stains that may or may not originate from a distinct bloodstain pattern. Often the terminal end of this narrow stain will display a thickening that represents the residual blood volume whose weight was not sufficient to continue its flow. These narrow stains will always extend in the direction of gravity's influence on the object as it rested at the time of blood flow.
- c. A **flow pattern** that does not extend downward on the object or

surface as observed indicates that the object or surface was moving during blood flow or that it was moved after blood flow had ceased.

## 2.3 Large Volume Patterns

### 2.3.1 Projected Patterns

- a. **Projected patterns** are produced by blood released under pressure such as arterial spurting. These patterns generally result from volumes of blood larger than those that produce passive drop stains (Section 2.2.1) or other dynamic patterns [i.e., impact patterns (Section 2.5), etc.].
- b. If the trajectory of a blood stream strikes an intervening target, a relatively large central stain is created that is surrounded by numerous spines of varying lengths. The appearance of this peripheral staining may be of value in assessing whether a volume of blood struck an object or surface forcefully. Projected blood streams that do not strike a vertical surface continue along individual parabolic flight paths until they deposit on a horizontal surface.
- c. **Projected patterns** produced by arterial spurting may sometimes be identified by their forceful appearance as an inverted V-shape pattern. Since the inverted V-shape, if present, is the result of the differential intravascular blood pressure that cycles as the heart contracts and relaxes, it may be possible to identify those portions of the patterns created by less forceful heartbeats.

### 2.3.2 Splashed Patterns

**Gush/Splashed patterns** are composed of relatively large central stains surrounded by spines and satellite stains and are observed when a relatively large volume of blood deposits on a surface with a minimum amount of force (i.e., gravity). Therefore, the peripherally located spines and satellite stains are generally fewer in number and the spines present are generally not as long and narrow as those of a projected pattern.

## 2.4 Blood Pools, Saturation, and Penetration Stains

- 2.4.1 **Blood pools** may be composed of either liquid and/or dried blood and may, under certain circumstances, contain clotted blood with or without observable serum separation.

2.4.2 Blood that collects on a porous surface, such as fabric, may be absorbed into the material to form a **saturation stain** and may display a mottled appearance due to the differential absorption across the surface. The stain may also display areas of complete absorption as well as areas of wet or encrusted staining.

2.4.3 **Penetration stains** are those which are deposited on one side of a surface and soak through to a second surface. Items such as clothing may display **penetration stains**. Unless the stain is of a recognizable pattern group around which experimental conditions can be designed, it may not be possible to estimate the amount of blood present within a **penetration bloodstain**. Ancillary information concerning the specific influences to which a particular substrate may have been subjected (e.g., single donned garment, layered donned garments, etc.) must be collected before making any surface of deposition assessments of a **penetration stain**.

## 2.5 Impact Patterns

2.5.1 **Impact patterns** are bloodstain patterns created when blood receives a blow or force resulting in the random distribution of smaller drops of blood. **Impact patterns** may be used to determine the point where the force encountered the blood source, i.e., the impact site <sup>[REFERENCES 10 - 12]</sup>.

2.5.2 While an **impact pattern** may display characteristics indicative of the nature of the blow or force that created it, determinations of the specific object and/or details of the impacting event generally require ancillary information. This information may include investigative information (e.g., crime scene reports, etc.), Reconstruction of the Point (Area) of Convergence (Section 3.1), Point (Area) of Origin (Section 3.2), and/or Experimentation (Section 6.5). However, in some circumstances, this ancillary information may prove to be insufficient for such determinations.

## 2.6 Expirated Patterns

2.6.1 **Expirated patterns** are created when blood is blown out of the nose, mouth, or wound as a result of air pressure and/or airflow and often display numerous, relatively small stain sizes that may vary in shape.

2.6.2 To differentiate between the individual stains of an **expirated** or **impact pattern**, serological tests for the presence of amylase may be performed. Additionally, a histological search for squamous epithelial cells may also be performed. The presence of bubble-rings within the individual stains may also be indicative of an **expirated pattern**.

2.6.3 The identification of **expired patterns** must be augmented with ancillary information such as photographs, emergency room and autopsy reports, etc. Should such documentation exist and fail to support the existence of a source for an **expired pattern**, this information may be used to support the conclusion that a specific stain pattern cannot be of expiratory origin.

## 2.7 Cast-Off Patterns

2.7.1 **Cast-off patterns** are bloodstain patterns created when blood is released or thrown from a blood-bearing object in motion and can be the result of two (2) basic actions: **arc cast-off patterns** are created when blood is released from an object through the influence of centrifugal acceleration, and **cessation, or stop-action, cast-off patterns** are created when blood is thrown from an object when the object's motion is abruptly stopped.

### 2.7.2 Arc Cast-off Patterns

- a. The individual stains of an **arc cast-off pattern** are generally distributed in a linear configuration and may be suitable for approximating the plane in space through which the blood-bearing object was moved.
- b. It may be possible to determine the object's direction of travel based on the shapes of the individual stains within the pattern [Section 2.2.1 (g)].
- c. The presence of an **arc cast-off pattern** on a piece of clothing or other evidence item may indicate its association with a blow or other source of cast-off action.

### 2.7.3 Cessation/Stop-action Cast-off Patterns

- a. The individual stains of a **cessation cast-off pattern** are generally smaller in size than those resulting from passive blood drops and can be a range of shapes. **Cessation cast-off patterns** generally do not display the linear arrangement of individual stains characteristic of arc cast-off patterns.
- b. Since **cessation cast-off patterns** are created as a blood-bearing object is abruptly stopped, such patterns could be produced by one or more of the impacts received by a blood source. If the blood source receiving the multiple blows is stationary, **cessation cast-off patterns** may be present within the context of other bloodstain

pattern types such as impact patterns (Section 2.5). In such circumstances, care must be taken in the selection of individual stains for impact site reconstruction (Section 3) to avoid use of stains of cessation cast-off origin.

#### 2.7.4 Determination of Number of Blows

The number of **cast-off patterns** present may be used to estimate the minimum number of blows received by a given blood source. However, because a blow applied to a blood source may not result in the creation of a **cast-off pattern**, it may not be possible to determine with certainty the specific number of blows received.

#### 2.7.5 Handedness Determinations

- a. Handedness determinations may be possible when the locations of the **cast-off patterns** are limited by the relative positions of the individuals and objects within the scene itself.
- b. In the absence of either ancillary information or spatial constraints at the scene, the appearance and location of **cast-off patterns** is not generally sufficient information on which to base a determination of the handedness of an individual wielding an object.

### 2.8 Perimeter/Skeletonized Stains

2.8.1 **Perimeter stains** are created when a partially dried bloodstain is disrupted by any subsequent action. Such stains retain their outer dried peripheral outlines but generally the central area will have been partially or completely removed.

2.8.2 Because drying time is dependent upon the surface on which blood is deposited and the environmental conditions to which it is then subjected, estimates of drying times must be experimentally determined (Section 6.5).

## 3 Determining Impact Sites [REFERENCES 1 - 3, 9 - 12, 14]

### 3.1 Point (Area) of Convergence (POC) Determination (Figure 2)

3.1.1 Conduct a general survey of the individual stains of the impact pattern to be reconstructed. Using a piece of string, rubber band, ruler, or other linear object, attempt to approximate the area, or areas, from which the

majority of stains appear to radiate (see Section 3.1.3). During the general survey, no permanent lines of convergence are made.

- 3.1.2 Based on this general survey, select individual stains from the impact pattern that display sharp margins and distinct elliptical shapes. Individual stains whose shapes and/or directions of travel indicate that they resulted from blood droplets whose flight paths were altered by gravity must not be selected. Such stains may include those on vertical surfaces whose direction of travel is perpendicular/near-perpendicular to the ground. Also, care must be taken in selecting circular to near-circular stains on horizontal surfaces as these stains may have been the result of slower moving blood droplets whose original flight path was altered to vertical/near-vertical by gravity.
- 3.1.3 For each of the stains selected, pass a string through the long axis of the stain extending it from just beyond the trailing edge of the stain to as far from the leading edge as necessary to extend beyond the margin of the entire pattern. This line of convergence approximates the plane through which a blood droplet traveled as it was passing over a surface prior to depositing. Once positioned, the string must be secured in place by tape at both ends being careful not to disturb the stain of interest or other features of the pattern. When practicable, lines may be drawn on the surface itself using a straight edge aligned as described or architects's tape (or other medium) may be used to designate this line of travel.
- 3.1.4 After positioning lines of convergence through a sufficient number of stains to well resolve any location on the surface where one or more lines intersect, one or more of these locations may represent a POC. Usually, such locations are areas on the surface through which a majority of the positioned lines intersect one another. This approximation of the POC may be verified again using a string, rubber band, ruler, etc. Hold one end of the selected device in the center of the intersection and rotate over the impact pattern to establish that the individual stains are generally bisected through their long axes as the directionality angle of the device is changed.



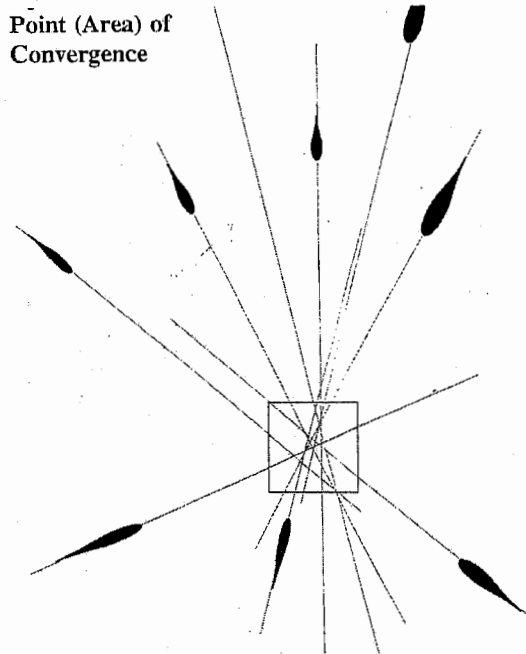


Figure 2: Point (Area) of Convergence

### 3.2 Point (Area) of Origin (POO) Determination

The point (area) representing the distance from the surface at which a blood source received an impact is termed the POO. Both the stringing (Section 3.2.1) and tangent methods (Section 7.2) are viable approaches for estimation of the POO of an impact stain. The selection of either method for a particular reconstruction is at the discretion of the BPAE.

#### 3.2.1 String Method

- a. Place a ring stand or other device at the POC to provide a vertical axis to assist in positioning the POO. The nature of the POC may require that the placement of this vertical be at or near the center of the intersections of the lines of convergences rather than directly over one or more of the intersections themselves. This ring stand placed at the approximated POC is the vertical axis in which the blood source received its impact at some yet undetermined distance away from the POC. It is often convenient to use a ruler or other measuring device as a part of this vertical for later reference purposes.

- b. Calculate the angle of impact ( $\theta$ ) from as many of the stains used for the determination of the POC as necessary to define a well resolved POO on the vertical axis (Section 7.1). Place a second string or other line material at the leading edge of the stain for which an angle of impact ( $\theta$ ) has been calculated [Section 2.2.1 (g)]. This string may be fixed in place with tape placed at the leading edge of the stain such that the string can be extended in the direction of the POC.
- c. Once appropriately affixed to the surface, the string must be pulled taut and a protractor used to place the string in the 3<sup>rd</sup> dimension of the blood droplet's original path of flight. To do this, align the base of the protractor along the stain's line of convergence with its center point at the leading edge of the stain [REFERENCE 17]. It may be necessary to reposition the edge of the protractor from the stain's established convergence line to accommodate the location of the approximated POC.
- d. Using the curved edge of the protractor, position the string at the reading in degrees that corresponds to the calculated angle of impact ( $\theta$ ) for that stain (Section 7.1). This is done by holding the string and sliding it up and down the vertical (e.g., ring stand or similar device) which is located at the POC. Once the string is positioned in accordance with the calculated angle of impact ( $\theta$ ), it must be affixed to the vertical at that location. This process must be repeated for a representative number of stains (Figure 3). Limiting angles may also be used to aid in the approximation of the POO (Section 5.2).

#### Point (Area) of Origin

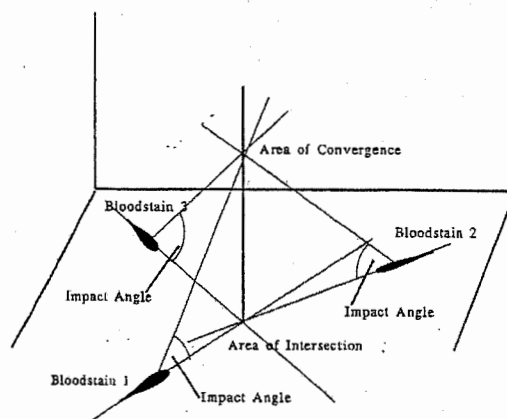


Figure 3: Point (Area) of Origin

- e. Upon positioning of the strings for the impact stain being reconstructed, measurements from the target surface to the string affixed closest to, and furthest from, should be made. This range of measurements representing the distance from the surface at which the blood source received the impact is termed the POO. If necessary, a best point estimate of the POO may be made by measuring to a point from the target surface at which a predominating number of the strings intersect the vertical or by calculating the average POO from a representative number of reconstructed stains.
- f. It may be possible to recognize overlapping impact patterns in situations in which the blood source changes positions between blows. If the changes in position of the blood source are relatively great between blows and result in repositioning of the source with relation to the target, the overlapping impact patterns may be identified based on their individual POCs.
- g. In situations in which there is relatively little movement of the blood source, or in which the repositioning of the blood source between blows is perpendicular to the target surface, it may not be possible to determine an individual POC for each impact pattern. The presence of a range of stain shapes at a common distance from the general POC of the pattern may indicate that multiple overlapping impact patterns are present. Such patterns should be assessed moving out from the general POC in concentric circles to establish that multiple stain shapes, and therefore, multiple impact angles, are present at common distances from the POC. This may indicate that more than one impact occurred, but each at a different distance from the surface. Such overlapping impact patterns may result in more than one POO at the common POC when reconstructed.

### 3.2.2 Tangent Method (See Section 7.2)

## 4 Temporal Considerations <sup>[REFERENCE 3]</sup>

Bloodstain patterns that are deposited on, or in association with, other patterns may provide information as to the order in which those patterns were created. However, because an existing bloodstain pattern may be greatly affected by later activities, care must be taken in making any sequencing determinations from overlapping bloodstain patterns. The sequence in which the bloodstain patterns were created may be determined from the following observations:

## 4.1 Overlapping Patterns

- 4.1.1 If one or more bloodstain patterns overlap on a target surface, it may be possible to determine which of the patterns was deposited first. Generally, once a bloodstain pattern is created, it is susceptible to being covered by any subsequent blood deposition or altered by any action that disrupts the previously deposited blood. In this way, a bloodstain pattern that is the first of an overlapping series may display an obscured, disrupted, or altered appearance as a result of the effects of the subsequent actions on its original or expected appearance.
- 4.1.2 Because the extent to which an existing bloodstain pattern is affected by later activities can vary greatly, care must be taken in making any sequencing determinations from overlapping bloodstain patterns. A preliminary assessment of the nature of the receiving surface and the period of time between pattern depositions may be necessary to determine if sequencing of the patterns is practicable. If the first pattern of an overlapping series is dry prior to its being subjected to subsequent activities, the disruption of this initial pattern may be minimal thus making it difficult to recognize this pattern as having been deposited first.

## 4.2 Non-Overlapping Patterns

It may be possible to sequence bloodstain patterns based on their positions relative to one another. Generally, this is only possible when ancillary information is available suggesting a possible sequence of events or providing specific pieces of information concerning injuries, location of the victim(s), etc. Such information may provide a context in which the locations of the bloodstain patterns is logical, and thereby a particular sequence of events is indicated (i.e., a series of projected patterns on a wall, each pattern successively lower than the previous, at the base of which is a body with an arterial injury).

## 4.3 Clotted Blood [REFERENCES 1, 2]

- 4.3.1 **Clotted blood** is blood that has undergone the physiological process of fibrin formation that congeals the solid elements of blood into a gelatinous mass. Blood that is shed from the body in sufficient volume to remain liquid for an extended period of time may begin to display clot formation. The minimum time necessary for clot formation to begin generally ranges from 3 to 15 minutes. This time course is dependent on many factors including the volume of blood deposited, the surface on which it is deposited, and the environmental conditions to which it is subjected.

- 4.3.2 Large blood pools that collect on nonporous surfaces may remain liquid for a sufficient period of time to display clot formation. Blood pools that undergo clot formation generally display large gelatinous masses with serum collections in the peripheral margins of the blood pool.
- 4.3.3 Individual stains that display clotted material may be produced when already clotted blood is subjected to disruption by a force or action. Such stains may display a central region of dense staining surrounded by a ring of less dense staining. This "bull's eye" or "fried egg" appearance is the result of the deposition of gelatinous clotted material with subsequent radial diffusion of the remaining liquid serum in porous material or continued clot retraction on nonporous surfaces.
- 4.3.4 Clotted material in the stain(s) of a bloodstain pattern may indicate that the blood that created the pattern was shed and remained undisturbed for a period of time sufficient for clot formation. In this way, the presence of clots within a bloodstain pattern may indicate that some period of time elapsed between the event(s) that resulted in bloodshed and clot formation. However, it may not be possible to determine the actual interval of time between the blood's shedding and clot formation unless ancillary information is available concerning the volume of blood shed and the environmental conditions to which it was subjected. As a result, while the presence of clotted blood within the stains of a bloodstain pattern may indicate a passage of time, care must be taken in any attempt to refine the estimate of such an elapsed interval. At the discretion of the BPAE, this interval may be experimentally determined (Section 6.5).

#### 4.4 Drying Time<sup>[REFERENCE 1, 2, 7]</sup>

- 4.4.1 Bloodstains dry from their perimeter inward toward their center. As the distal margins of the stain dry, they become more resistant to disruption or removal than the stain's still wet interior. As a general guide, a minimum of 1 minute is required for sufficient drying to create a perimeter stain (Section 2.8).
- 4.4.2 Because the **drying time** of blood is dependent upon the volume of blood deposited, the surface on which the blood is deposited, and the environmental conditions to which it is subjected, this interval may be experimentally determined at the discretion of the BPAE (Section 6.5).

## 5 Miscellaneous Considerations

Patterns and techniques that may also provide information through BPA include:

## 5.1 Voids <sup>[REFERENCE 1]</sup>

**Voids** are areas within bloodstain patterns that display no staining where it would be expected based on adjacent areas of the pattern. **Voids** may indicate that one or more unknown persons or things were present at the site and that the staining corresponding to the voided area may or may not be on that person or thing that created the **void**.

## 5.2 Limiting Angles

Some impact patterns (Section 2.5) may provide information as to where in space a blood source received a blow. **Limiting angles** may be established by aligning a straight edge with the margin of any void (Section 5.1) within the impact pattern and the edge of the intervening object that gave rise to the void. This establishes a plane that extends back through the vertical containing the POO of the impact pattern (Section 3.2). Multiple **limiting angles** and or reconstructed spatter stains are necessary for determination of the POO. The use of **limiting angles** may not be possible if the intervening object that gave rise to the void is not in, or can not at least be returned to, its original position (Figure 4).

# 6. Environmental Considerations

## 6.1 Animal/Insect Activity <sup>[REFERENCE 1]</sup>

Care must be taken in evaluating bloodstain patterns present at locations where animal and/or insect activity may have created additional patterns and/or altered pre-existing patterns. When possible, use ancillary information to determine whether animals and/or insects were observed or are suspected to have been present or to have had access to those locations at which bloodstain patterns are observed. As a general practice, and especially in the absence of information concerning potential animal/insect activity, stain patterns must be evaluated in the context of possibly having been created by such activities.

## 6.2 Moisture

The presence of moisture on a surface, the introduction of other body fluids into a blood drop as it is shed, or the absorption of moisture into a bloodstain after it is deposited, can alter the appearance of a stain. Effectively, the introduction of this additional moisture, by whatever means, will dilute the blood or bloodstain and may result in its appearing less dense. In situations in which it is believed that a diluted bloodstain pattern is present, care must be taken in evaluating the observed pattern.

### 6.3 Temperature

Extremes in temperature may give rise to changes in the appearance of bloodstain patterns. Excessive heat may discolor deposited bloodstains and possibly result in sufficient dehydration to render them friable and susceptible to dislodgment by routine activity. At extremely low temperatures, bloodstains may become sufficiently crystalline to render them susceptible to dislodgment by the same kinds of activities. Care must therefore be taken in situations in which deposited bloodstains are suspected to have been exposed to such extremes in temperature.

### 6.4 Enhancement Techniques [REFERENCES 1, 2, 18]

In some situations, blood enhancement techniques may be needed to search for or better visualize bloodstain patterns. Numerous chemicals are available for the enhancement of latent and patent bloodstain patterns including the following.

- Amido Black (Methanol Base)
- Amid Black (Water Base)
- Coomassie Brilliant Blue
- Diaminobenzidine (DAB)
- Fluorescein [REFERENCE 19]
- Leucocrystal Violet (LCV)
- Leucomalachite Green (LMG)
- Luminol [REFERENCES 20 - 23]
- Tetramethylbenzidine (TMB)

### 6.5 Experimentation [REFERENCES 1, 2, 8, 14, 24]

The design of all BPA experiments must simulate, as closely as possible, actual conditions under which the bloodstain patterns were created. All experimental designs must be reviewed by a second qualified BPAE prior to being conducted. Once an appropriate experimental design has been fashioned and reviewed, it must be described as a part of the casework documentation together with the data generated from the experiments. Supporting photographic or other documentation may be made of all or any part of the experiment as deemed necessary by the BPAE.

### 6.6 Models

When BPA analysis is being conducted at a crime scene or on evidence submitted to the Laboratory, models may be of value in recognizing the special relations between/among bloodstain patterns. Depending on the circumstances surrounding the BPA and the resources available to the BPAE, a mannequin or another individual may serve as a model for demonstration purposes. Appropriate safety

precautions must be observed if human models are to be used.

## 7 Calculations

### 7.1 Angle of Impact Calculations [REFERENCE 1, 2, 10, 16, 25]

- 7.1.1 Measure the width (W), or short axis dimension, of an individual stain within the impact pattern. As necessary, measure this dimension from a point midway between the trough and apex of any scalloping on one edge to the corresponding point on the opposite edge. This measurement must be made at the widest point of the stain's short dimension (Figure 4).

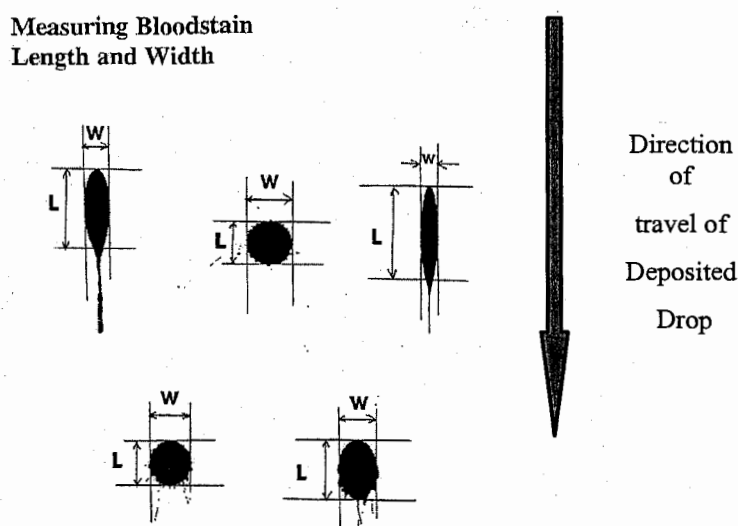


Figure 4: Stain Measurements

- 7.1.2 Measure the length (L), or long axis dimension, of the same stain. When measuring elongated stains measure this dimension from the stain's lesser disrupted edge (the edge of the stain deposited first) to a point in the stain's trailing margin that delineates its true elliptical shape (Section 2.2.1.g). Do not include in this measurement the tail and wave cast-off portions of the stain. Inclusion of these trailing edge characteristics in the measurement of length may result in the under estimation of the impact angle of a stain (Figure 4).
- 7.1.3 Divide the measured width of the stain by its length (W/L). This value is the Sine for the impact angle ( $\theta$ ). (Figure 5)



**Example:**

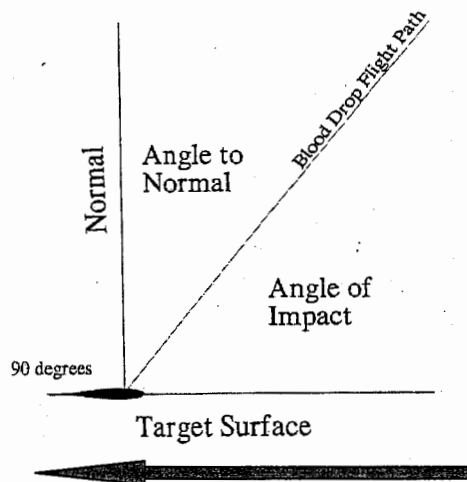
Stain width (W) = 5 mm  
Stain Length (L) = 10 mm

$$\text{Sine of Impact Angle } (\theta) = W/L$$

$$W/L = 5 \text{ mm}/10 \text{ mm}$$

$$\text{Sine of Impact Angle } (\theta) = 0.5$$

**Angle of Impact**



**Direction of Travel of Deposited Drop**

Figure 5: Angle of Impact

- a. Using a scientific calculator, use the Inverse Sine (ASN or  $\text{Sin}^{-1}$ ) to calculate the impact angle ( $\theta$ ) in degrees.

**Example:**

$$\text{Sine of Impact Angle } (\theta) = 0.5$$

$$\text{Impact Angle } (\theta) = 30^\circ$$

- b. Alternatively, a trigonometric table of Sine functions (Appendix 1), may be used to find the Sine value of the impact angle ( $\theta$ ) in the column of Sine values for the given angle in degrees. If the Sine for this angle is not present in the table, the nearest angle value in degrees may be used to approximate the impact angle ( $\theta$ ), or the value may be interpolated using the two (2) table values that bracket the Sine of the impact angle of interest.
- c. Using reference stains created at known angles, it may be possible to estimate the angle of impact of a questioned stain.

## 7.2 Tangent Method <sup>[REFERENCE 1]</sup>

The point (area) representing the distance from the surface at which a blood source received an impact is termed the POO. Both the stringing (Section 3.2.1) and tangent methods (Section 7.2) are viable approaches for estimation of the POO of an impact stain. The selection of either method for a particular reconstruction is at the discretion of the BPAE

- 7.2.1 Measure the distance from the leading edge of a stain for which the line of convergence has been established (Section 3.1.3) to its point of intersection with the POC (Figure 3).
- 7.2.2 The nature of the intersecting lines of convergence for all of the individual stains included in the POC determination may require that this intersection point with the POC be approximated at or near a point in the center of the intersecting lines rather than at any single intersection itself.
- 7.2.3 The measurement obtained from the leading edge of a stain to the approximate POC (Section 3.1.4) is then multiplied by the tangent of the stain's impact angle,  $\theta$ , calculated in Section 7.1.
  - a. If a scientific calculator is available, the value of the tangent for the stain's impact angle can be determined by entering the calculated value obtained for the impact angle,  $\theta$ , in degrees and then using the Tangent function. The product of this multiplication is the calculated distance from the target surface that the blood source received the impact. Because this calculation is based on a single stain, it must be repeated for a number of individual stains from the impact pattern being reconstructed.

**Example:**

Impact Angle  $\theta = 30^\circ$

Measured Distance from Stain to POC = 60 cm

Tangent of Impact Angle  $30^\circ = 0.577$

$$\begin{array}{ccc} 0.577 & \times & 60 \text{ cm} \\ \text{Tangent of Impact} & & \text{Measured} \\ \text{Angle } 30^\circ & & \text{Distance} \end{array}$$

$$= 35 \text{ cm}$$

Distance impact site is from  
surface on which stains are  
deposited

- b. Alternatively, a trigonometric table of Tangent functions [Appendix 2], may be used to find the value of the impact angle,  $\theta$ , in the column of values for given angles in degrees. If the value in degrees for this angle is not present in the table, the nearest angle value in degrees may be used to approximate the tangent ratio or the value itself may be interpolated using the two (2) table values that bracket the impact angle of interest.

**LIMITATIONS**

Prior to bloodletting, it is not possible using bloodstain pattern information alone to determine the position(s), movement(s), or action(s) of the participants in a particular incident. Only those actions and movements made or taken by the participants that resulted in either the deposition of blood on objects at the scene or the disruption of blood already present on these surfaces may provide pattern information suitable for examination.

**SAFETY**

All evidence containing or contaminated with blood or other potentially infectious materials will be considered infectious regardless of the perceived status of the source individual or the age of the material. All DNAU I personnel who work with such material will follow the "Bloodborne Pathogen Exposure Control Plan" found in the most current revision of the FBI Laboratory Division Safety Manual at **G:\labshare\Safety**.