4

Bloodstain Patterns

Chapter Overview

When a crime involves violence, there is usually blood present at the scene of that crime. Many times, the patterns of the bloodstains can be studied and used to postulate what events took place to create them. This chapter will discuss bloodstain pattern analysis, how it is performed, and how it can be interpreted and used to reconstruct a crime. All the topics we discussed in the previous chapters apply, including methods of documentation of scenes and collection of evidence. Given the nature of the evidence and its interpretation, it is no surprise that the digital images collected at the scene are particularly critical.

Chapter 4

Bloodstain Patterns*

Stuart H. James, Paul E. Kish, and T. Paulette Sutton

Chapter Outline

4.1 Bloodstain Pattern Evidence

The geometric analysis of human bloodstain patterns at crime scenes is not a new idea, but it has acquired much greater recognition over the past several decades. **Bloodstain pattern analysis** should be viewed as a forensic tool that assists the

* This chapter is based on Chapter 12, "Recognition of Bloodstain Patterns," by Stuart H. James, Paul E. Kish, and T. Paulette Sutton, as published in the third edition of this text.

SIDEBAR 4.1. CAREER PREPARATION AND EXPECTATIONS

Bloodstain analysts represent a range of forensic scientists and crime scene investigators with diverse levels of education. The courts have accepted testimony from individuals with strong backgrounds in chemistry, biology, and physics, many of whom possess degrees in science or forensic medicine. Many of these individuals are employed in crime laboratories or medical examiner offices that have crime scene responsibilities. Crime scene investigators, evidence technicians, and detectives who do not necessarily possess scientific backgrounds have also offered expert testimony. There are also training courses available for bloodstain pattern analysis both at the university and professional levels.

It is worth noting that completion of basic and advanced courses in bloodstain pattern analysis does not imply that an individual is a qualified bloodstain analyst. The formal education must be coupled with years of experience with crime scenes and evidence examination along with regular attendance at scientific seminars. The primary professional organization for the field is the International Association of Bloodstain Pattern Analysts (**IABPA**, http://www.iabpa.org/).

On the job, bloodstain pattern analysts can work with a police agency or a public laboratory, or as a private consultant. Often, these forensic scientists are specialists in crime scene investigation and processing. As such, analysts are frequently on call and can work long and difficult hours, particularly with big cases.

investigator or the forensic scientist to better understand what took place and what could not have taken place during a bloodshed event. In this sense, is it is a form of crime scene reconstruction and can be used as we discussed in the last chapter. The information obtained from the analysis of bloodstain patterns may assist in apprehending a suspect, corroborate a witness's statement, assist in interrogating suspects, and allow for the reconstruction of past events. As with any tool, bloodstain pattern analysis has its strengths and weaknesses. The analysis will only be as valid as the information available and the ability of the examiner performing the analysis. (For a discussion of career preparation for blood stain analysis, see Sidebar 4.1.)

4.2 History of Bloodstain Pattern Analysis

The analysis of bloodstains and patterns has been documented in books, journals, and articles for centuries (see Sidebar 4.2), but the science of bloodstain pattern analysis in modern form emerged in the 1800s. Original research and experimentation with bloodstains and patterns was done by the French scientist Dr. Victor Balthazard, whom we met in Chapter 1, and his associates, who presented the material as a paper at the 22nd Congress of Forensic Medicine in 1939. The use of bloodstain pattern analysis as a recognized forensic discipline in the modern era dates back to 1955, when Dr. Paul Kirk of the University of California at Berkeley submitted an affidavit of his examination of bloodstain evidence and findings in the case of *State of Ohio v. Samuel Sheppard*. This was a significant milestone in the recognition of bloodstain evidence by the American legal system. In 2002, the Scientific Working Group on

SIDEBAR 4.2. HISTORICAL NOTE: THE FUGITIVE

This famous case became the real-life inspiration for a television series (1963–1967) and for a movie starring Harrison Ford (1993). Dr. Sam Sheppard was convicted of killing his wife in 1954, and the case continued on until 2002. Crime scene investigation and bloodstain patterns provided the key evidence in the case. Sheppard was an osteopathic physician living in a suburb of Cleveland with his wife Marilyn, who was 31 and pregnant on the night of the murder, July 4, 1954. Sheppard claimed to have been asleep on the couch when he awoke to what he thought were his wife's screams. He raced upstairs and found Marilyn on the bed, severely beaten with blood soaked into the bedclothes and spattered all around the room. He told police that he struggled with a bushy-haired man and was knocked unconscious. Sheppard claimed that, after he awoke, he checked his wife's pulse before setting off in pursuit of the killer. He caught the man on the beach and scuffled again, and again was knocked unconscious. He awoke later and called a neighbor, who discovered the body and notified police. While all of this transpired, the Sheppards' young son remained asleep in the room next to his parent's bedroom, where the murder occurred. The way in which the body was found suggested sexual assault, but hints of burglary and drug-related robbery were also discovered. A small green bag was found later on the beach that contained Sheppard's watch and other items. The watch was spattered with blood, suggesting that the wearer was in the room where and when the killing occurred.

Sheppard was convicted and sentenced to life imprisonment. In 1966, the U.S. Supreme Court ordered Sheppard released on the basis that his trial was prejudiced by publicity and errors. The second trial began in 1966, by which time more forensic capability existed. Paul Kirk, a respected forensic scientist of the time, reviewed the evidence, principally blood spatter, and concluded that Sheppard was likely innocent; however, he did not have access to DNA evidence, which would not be available for another three decades. Sheppard was found not guilty and released, but he died in 1970. In the 1990s, Sheppard's son sought further forensic investigation. Forensic profilers, anthropologists, DNA analysts, and crime scene investigators became involved but no clear consensus emerged. Legal actions continued into the new century.

Bloodstain Pattern Analysis (**SWGSTAIN**, www.swgstain.org/) was formed to further develop and standardize bloodstain pattern analysis. This website has a link to a list of the most current terminology used in bloodstain pattern analysis.

4.3 Properties of Human Blood

4.3.1 Biological Properties

Fluid blood circulates throughout the body by way of the heart, arteries, veins, and capillaries. It transports oxygen, electrolytes, nourishment, hormones, vitamins, and antibodies to tissues and transports waste products from tissues to the excretory organs. Blood consists of a fluid portion referred to as **plasma** that contains cellular components consisting of red blood cells, white blood cells, and platelets.

When blood has had the opportunity to clot, the fluid or liquid portion of the blood that does not clot is referred to as **serum**. Red blood cells (**RBCs** or **erythrocytes**) transport oxygen from the lungs via the arterial system and return carbon dioxide to the lungs for expiration via the venous system. White blood cells (**WBCs** or **leukocytes**) assist with defense against foreign substances and infection. The nuclei of the white blood cells are the sources of DNA in the blood. **Platelets** are major components of the clotting mechanism of blood. In normal individuals, cellular components comprise approximately 45% of the total blood volume, which ranges in healthy adults from 4.5 to 6.0 liters. A person who loses significant amounts of blood can die by bleeding to death, or **exsanguination**.

4.3.2 Physical Properties of Blood

Exposed human blood is not unlike other commonly encountered fluids. It will act in a predictable manner when subjected to external forces. Blood, whether a single drop or large volume, is held together by strong cohesive molecular forces that produce a surface tension within each drop and on the external surface. **Surface tension** is defined as the force that pulls the surface molecules of a liquid toward its interior, decreasing the surface area and causing the liquid to resist penetration. The surface tension of blood is slightly less than that of water. By comparison, one can appreciate the high surface tension of liquid mercury, which is almost 10 times greater than that of blood. To create spatters of blood, an external force must overcome the surface tension of the blood. The shape of a blood drop in air is directly related to the molecular cohesive forces acting upon the surface of the drop. These forces cause the drop to assume the configuration of a spheroid. Blood, like all fluids, does not fall in a teardrop configuration, even though many artists portray raindrops and other fluids in that manner on television and in newspapers (Figure 4.1).

A passive drop of blood is created when the volume of the drop increases to a point where the gravitational attraction acting on the drop overcomes the molecular cohesive forces of the blood source. The volume required to produce these free-falling drops of blood is a function of the type of surface and the surface area from which the blood drop has originated. For example, research and experimentation have shown that the volume of a passive drop of blood falling through air from a fingertip will be larger than a drop that originates from a hypodermic needle and smaller than a drop originating from a surface such as a baseball bat. The volume of a typical or average drop of blood has been reported to be about 0.05 milliliters (mL)

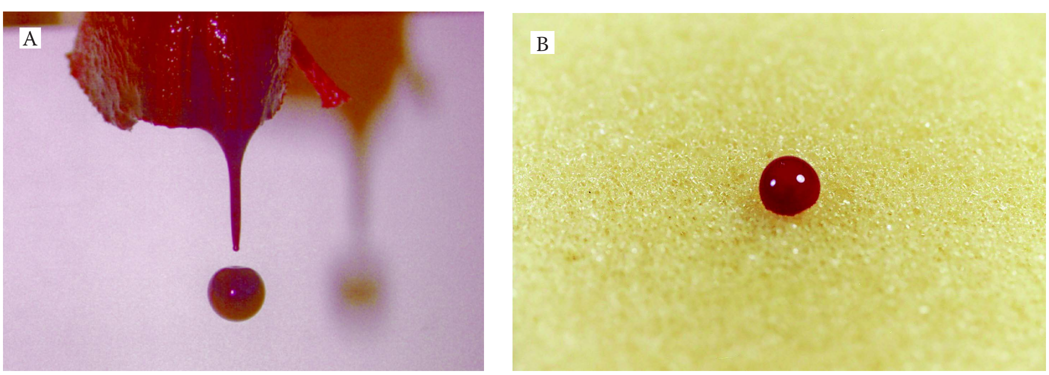

Figure 4.1 (A) Spheroid shape of a blood droplet due to the effect of surface tension as it falls through the air after separating from a blood-soaked cloth. (B) Spheroid shape of a blood droplet on cloth due to the effect of surface tension.

(0.0017 ounces), with an average diameter of about 4.5 millimeters (mm) (while in air). These reported measurements can vary as a function of the surface from which the blood has fallen and the rate at which the blood accumulates.

The mutual attraction of the molecules of blood is due to cohesive forces. **Viscosity** is defined as resistance to change of form or flow. The more viscous a fluid, the more slowly it flows. Blood is approximately six times more viscous than water and has a specific gravity slightly higher than water. **Specific gravity** is defined as the weight of a substance relative to the weight of an equal volume of water. These physical properties of blood tend to maintain the stability of exposed blood or blood drops and help them to resist alteration or disruption.

A blood drop falling through air will increase its velocity until the force of air resistance that opposes the drop is equal to the force of the downward gravitational pull. At this point, the drop achieves its **terminal velocity**. One can easily demonstrate that free-falling drops of blood will produce bloodstains of increasing diameters when allowed to drop from increasing increments of height onto smooth, hard cardboard. The measured diameters range from 13.0 to 21.5 mm over a dropping range of 6 in. to 7 ft. Blood drops that fall distances greater than 7 ft will not produce stains with any appreciable increases in diameter. However, in a practical sense, it is not possible to establish with a high degree of accuracy the distance that a passive drop of blood has fallen at a crime scene, as the volume of the original drop is not known.

4.4 Formation of Bloodstains and Bloodstain Patterns

4.4.1 Target Surface Considerations

Exposed blood has an invisible outer skin referred to as its surface tension. To create smaller blood droplets or spatter from a volume of blood, this surface tension must be disturbed in some way. Although a single drop of blood falling through air is affected by the forces of gravity and air resistance, these forces do not overcome the surface tension of the blood. No matter how far a drop of blood falls, it will not break into smaller droplets or spatters unless something disrupts the surface tension. One factor in breaking the surface tension of a blood drop is the physical nature of the target surface the drop strikes. Generally, a hard, smooth, nonporous surface, such as clean glass or smooth tile, will create little if any spatter (Figure 4.2A), in contrast to a surface with a rough texture such as wood or concrete that can create a significant amount of spatter (Figure 4.2B). Rough surfaces have protuberances

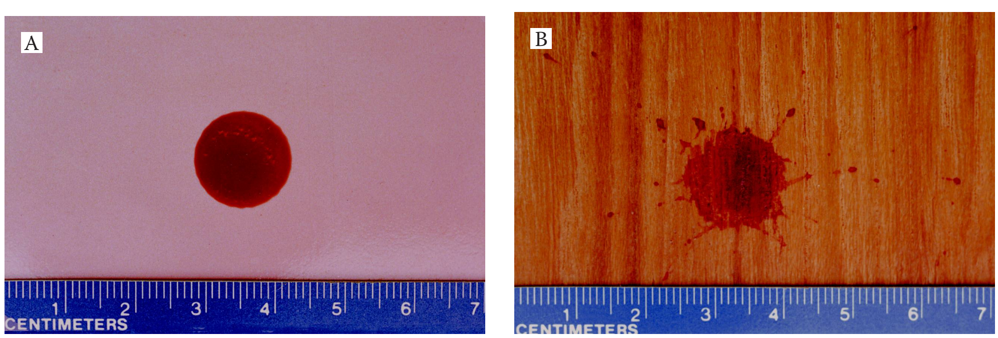

Figure 4.2 Effect of target surface texture on bloodstain characteristics and degree of spatter produced from single drops of blood falling vertically 30 inches onto (A) smooth polished tile and (B) wood paneling.

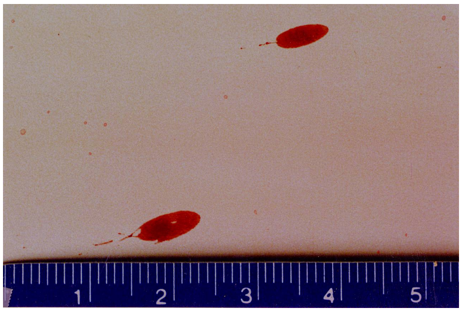

Figure 4.3 The direction of travel of these bloodstains is from right to left and downward, as determined by the characteristics of the leading edge of the stains.

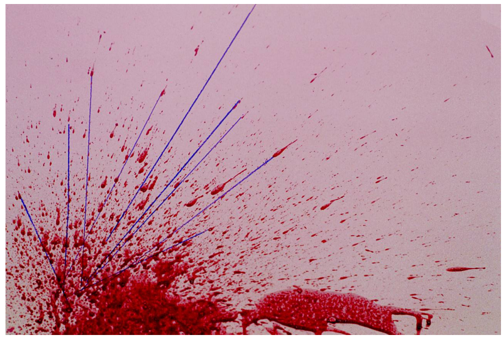

Figure 4.4 Representation of the point or area of convergence of bloodstains on a wall by drawing straight lines through the long axes of the stains.

that rupture the surface tension of the blood drop and produce spatter and irregularly shaped parent stains with spiny or serrated edges. The effect of target texture must be understood and may require additional testing.

4.4.2 Size, Shape, and Directionality

The geometry of individual bloodstains will generally allow the analyst to determine their direction of flight prior to impacting an object. This is done by examining the edge characteristics of individual stains (Figure 4.3). The narrow end of an elongated bloodstain usually points in the direction of travel. After the **directionality** of several bloodstains has been determined, an area or point of convergence may be established by simply drawing straight lines through the long axes of the bloodstains (Figure 4.4). The area where these lines converge represents the relative location of the blood source in a two-dimensional perspective on the *x*- and *y*-axes. This **area of convergence** will be an area, not an exact point.

The **area of origin** or the location of the blood source in a three-dimensional perspective can also be determined. By establishing the impact angles of representative bloodstains and projecting their trajectories back to a common axis extended at 90° up from the two-dimensional area of convergence along the *z*-axis, an approximate location of where the blood source was when it was impacted may be established. Diagrammatic representations of convergence and origin utilizing the *x*-, *y*-, and *z*-axes are shown in Figure 4.5.

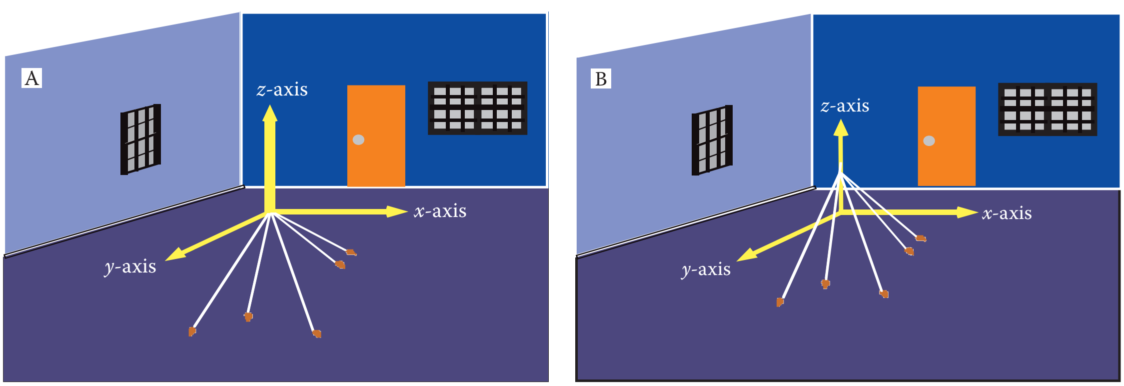

Figure 4.5 Graphical representation of (A) the point or area of convergence with the *x*- and *y*-axes and (B) the point or area of origin in space along the *z*-axis of the bloodstains with the use of the angle of impact of the stains.

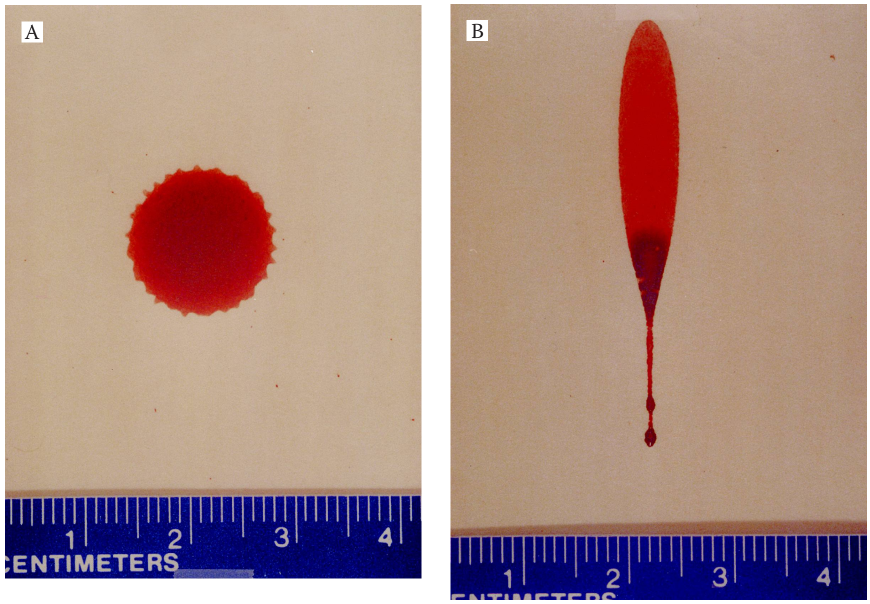

Figure 4.6 The shape of a bloodstain resulting from a single drop of blood falling 30 inches onto smooth cardboard at (A) 90° and (B) 10°.

If the **angle of impact** is 90°, the resulting bloodstain generally will be circular in shape (Figure 4.6A). Blood drops that strike a target at an angle less than 90° will create elliptical bloodstains (Figure 4.6B). A mathematical relationship exists between the width and length of an elliptical bloodstain that allows for the calculation of the angle of impact for the original spherical drop of blood. This calculation is accomplished by measuring the width and the length of the bloodstain (Figure 4.7). The width measurement is divided by the length measurement to produce a ratio number less than 1. This ratio is the arcsine of the impact angle, and the impact angle of the bloodstain can be determined by simple calculations. For a circular bloodstain,

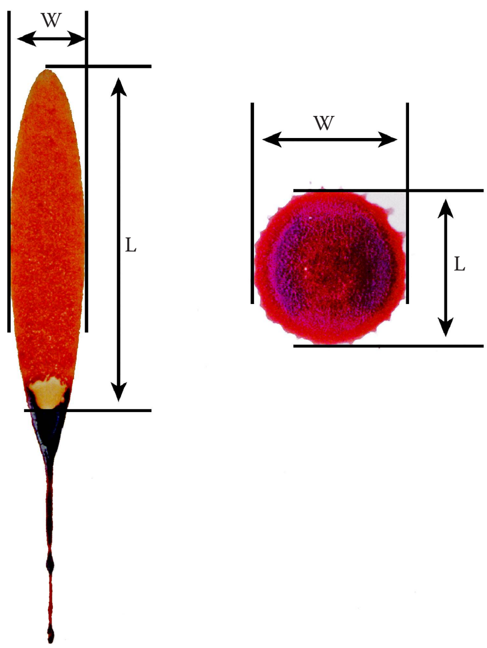

Figure 4.7 Measurement of the width and length of bloodstains.

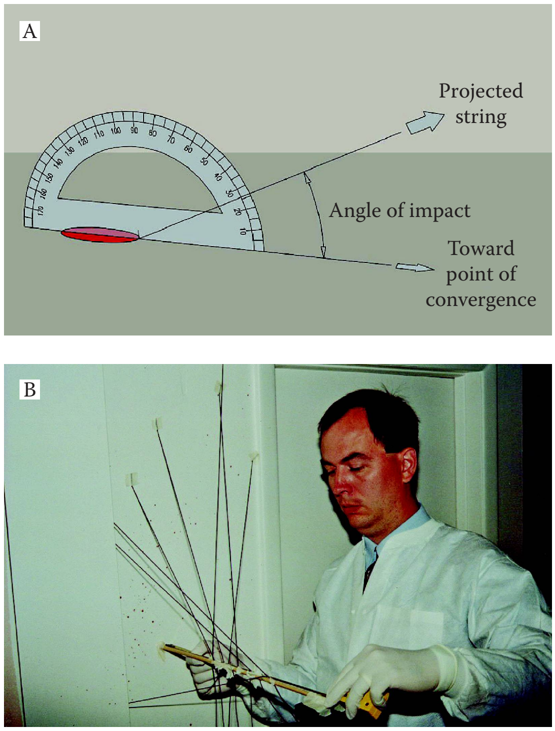

Figure 4.8 (A) Method of use of a protractor with the calculated angle of impact to determine the area of origin of a bloodstain. (Courtesy of Alexei Pace, Marsaxlokk, Malta.) (B) Elastic strings placed at the base of selected bloodstains and projected along the *z*-axis to represent the three-dimensional point or area of origin of bloodstains.

the width and length are equal and thus the ratio is 1.0, which corresponds to an impact angle of 90°. For an elliptical bloodstain whose width is one half its length, the width-to-length ratio is 0.5, which corresponds to an impact angle of 30°.

After establishing the angle of impact for each of the bloodstains, the three-dimensional origin of the bloodstain pattern can be determined. One method, known as *stringing*, involves placing elastic strings at the base of each bloodstain and projecting these strings back to the axis that has been extended 90° up or away from the two-dimensional area of convergence. This is accomplished by placing a protractor on each string and then lifting the string until it corresponds with the previously determined impact angle. The string is then secured to the axis placed at the two-dimensional area of convergence. This is repeated for each of the selected bloodstains (Figure 4.8). It is worth noting that the use of strings is being replaced by automated digital methods, but the concepts that underlie both approaches are the same.

The calculated area of origin is always higher than the actual origin of the bloodstains because of the gravitational attraction affecting the spatters while in flight. This gives the analyst the maximum possible height of the blood source. In practical terms, the analyst is attempting to determine how far above or away from a surface the blood source (victim) was located when the spatter-producing event occurred or whether the victim was standing, lying down, or sitting in a chair when the blood was spattered. This method for determining the location of a blood source is not always necessary. For instance, if no blood spatter appears on a table top or chair seat, but spatter associated with a gunshot is found on the underside of the table and chair, then the obvious conclusion is that the victim was on or near the floor when shot. Common sense and quality observations will often resolve the question of where someone was when injuries were inflicted.

4.4.3 Spattered Blood

Spattered blood is defined as a random distribution of bloodstains that vary in size that may be produced by a variety of mechanisms. The quantity and size of spatters produced by a single mechanism can vary significantly. The amount of available blood and the amount of force applied to the blood affect the size range of spatters. Spatter is created when sufficient force is available to overcome the surface tension of the blood. The amount of force applied to a source of blood and the size of the resulting spatter vary considerably with gunshot, beating, and stabbing events. The size range of spatter produced by any one mechanism may also vary considerably. Frequently, a single mechanism will create spatters whose size will fit all the categories as outlined in Figure 4.9. Upon examination, the analyst must identify a pattern as a spatter before attempting to ascertain the specific mechanism that created it. A single small stain does not constitute a spatter pattern. Determining the mechanism that created a spatter pattern normally requires more information than merely a look at the pattern; therefore, it is advisable to refer to bloodstain patterns as simply "spatter patterns" until all available information has been reviewed. The identification and analysis of blood spatter patterns are significant for the following reasons:

- Spattered blood may allow for the determination of an area or location of the origin of the blood source when the spatter-producing event occurred.
- If found on a suspect's clothing, spattered blood may place that person at the scene of a violent altercation.
- Spattered blood may allow for determination of the specific mechanism by which the pattern was created.

After identifying small bloodstains as a spatter pattern and gathering pertinent scene, medical, and case-related facts, the analyst may then be able to establish the specific mechanisms by which the pattern was created. The size, quantity, and distribution of these spatters vary depending upon:

- The quantity of blood subjected to impact
- The force of the impact
- The texture of the surface impacted by the blood

In a laboratory environment, the amount of force applied to a blood source and the quantity of blood impacted are easily controlled. However, in actual casework, these factors are not known. In the category of spatter created by an impact mechanism, all three of the mechanisms may produce the similar size ranges of spatter, depending on these factors.

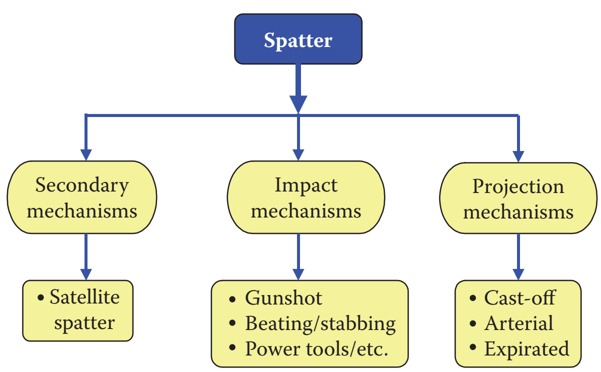

Figure 4.9 Categories of blood spatters based on the mechanisms by which they were created.

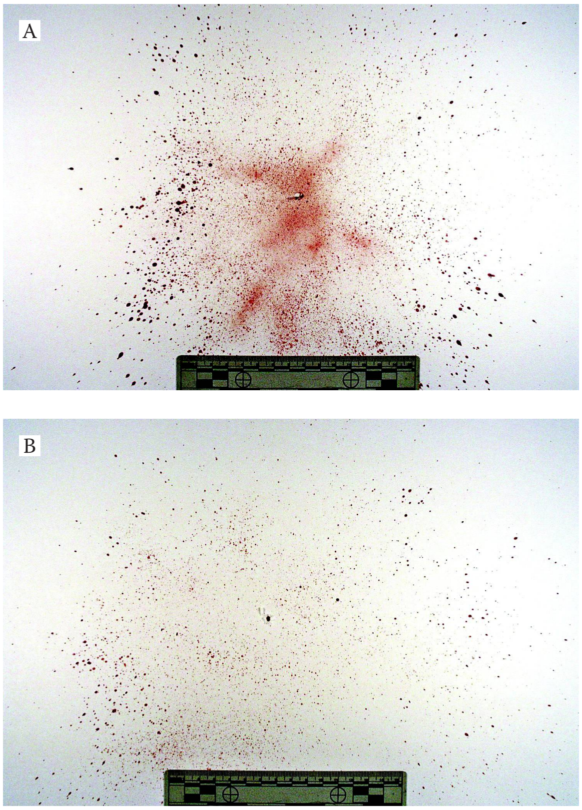

Figure 4.10 (A) Forward spatter associated with gunshot. Note the mistlike dispersion of the minute stains sometimes referred to as the "rouging effect." This misting is not often seen in casework. (B) Back spatter associated with gunshot; this is generally seen in less quantity than forward spatter.

4.4.4 Impact Spatter Associated with Gunshot

Impact spatter that is associated with gunshot may produce minute spatters of blood less than 0.1 mm in diameter that are often referred to by analysts as *mist-like dispersions*. This mist-like spatter is not frequently seen, but when observed it is indicative of gunshot. This **misting** effect is not observed in spatter patterns associated with beatings, stabbings, or the production of **satellite spatter** created by blood dripping into blood. Impact spatters associated with gunshot often exhibit a wide size range, from less than 0.1 mm up to several millimeters or more. The size range is dependent on the quantity of available blood, the caliber of the weapon, the location and number of shots, and impeding factors, such as hair, clothing, etc.

Impact spatter of this type is most commonly associated with gunshot, but may also be produced in cases involving explosions, power tools, high-speed machinery injuries, and occasionally high-speed automobile collisions (Figure 4.10). In gunshot cases, two sources can account for impact spatter. When associated with an entrance wound, it is referred to as **back spatter**. This spatter may be found on the weapon and the shooter, especially on the hand and arm areas. Conversely, when the impact spatter is associated with an exit wound, it is referred to as **forward spatter** (Figures 4.10 and 4.11). No forward spatter is produced in cases where the projectile does not exit the body. Generally, the mechanisms that create impact blood spatter will create a variety of sizes of bloodstains that would fit into the categories of impact spatter associated with beating and stabbing events, as well as spatter produced by expiration of blood.

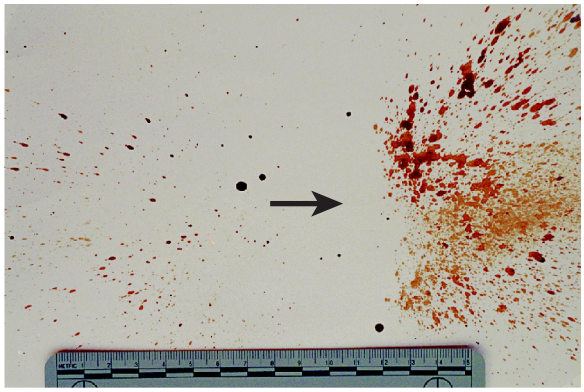

Figure 4.11 Horizontal perspective of back spatter and forward spatter produced by gunshot mechanism. The arrow indicates the direction of the projectile. Note the larger quantity and distribution of forward spatter.

4.4.5 Impact Spatter Associated with Beating and Stabbing

Impact spatter associated with beating and stabbing events generally exhibits a size range from 1 to 3 mm in diameter. The spatters may be smaller or larger than this general range, depending on the force of the impact and the quantity of available exposed blood (Figure 4.12). Exposed blood, such as on the skin as a result of a wound, must exist for impact spatters to be created. The blood or bloodied area itself does not have to receive the impact; for example, if a victim has blood on his or her face, a blow struck to back of the head can translate enough force to spatter

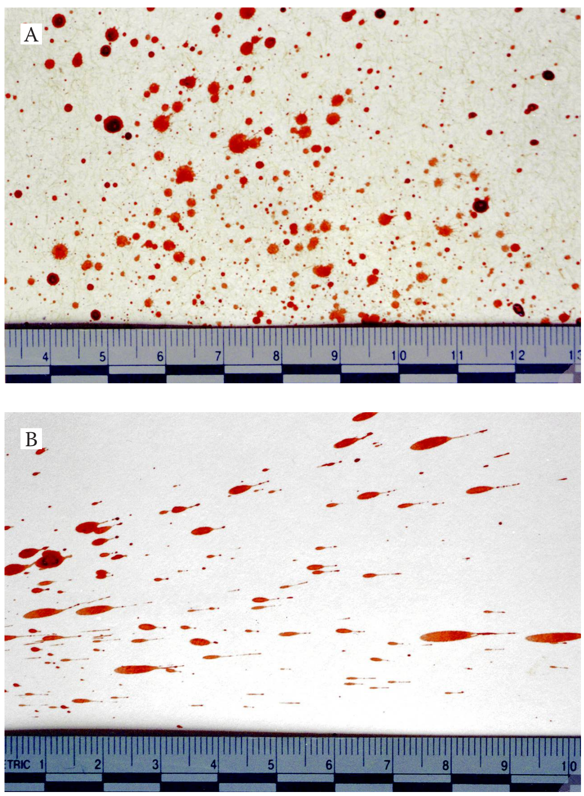

Figure 4.12 Impact spatter produced by beating mechanism on (A) smooth cardboard vertical surface and (B) smooth cardboard horizontal surface.

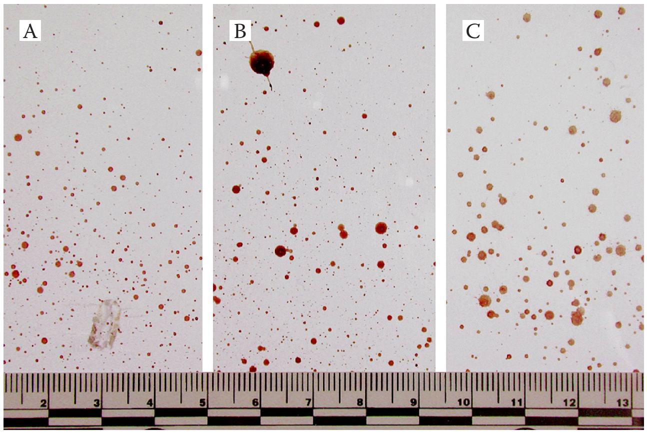

Figure 4.13 Comparison of size ranges of spatters produced by (A) gunshot, (B) expirated blood, and (C) beating.

the blood on the front of the head. The weapon used in the assault, whether a sharp object (e.g., knife, glass) or a blunt object (e.g., fist, bat, concrete block) and the number of blows inflicted have effects on the resulting pattern. Mechanisms other than a beating or a stabbing, such as gunshots, expiration of blood, and satellite spattering, may also produce spatter in the size range of less than 1 to 3 mm.

In certain situations, multiple mechanisms may exist, such as any combination of gunshot, beating, stabbing, expirated blood, or satellite spatter resulting from blood dripping onto surfaces. The size ranges of spatters produced by these mechanisms can be similar, so it may not be possible to determine which mechanism produced a specific pattern. Figures 4.12 and 4.13 show how the sizes of these spatters overlap with respect to gunshot, expirated, and beating mechanisms. For this reason, the analyst should consider all possible mechanisms for the production of spatter and utilize all available information. Sometimes, two or more plausible explanations may exist that can explain a spatter pattern, and this must be acknowledged by the analyst. Spatter created by a projection mechanism is produced by the disruption of the surface tension of the blood without an impact (e.g., castoff, arterial, and expirated), as shown in Figure 4.9. These patterns will be discussed in greater detail later in the chapter.

4.4.6 Significance of Satellite Spatters Resulting from Dripped Blood

Single drops of blood will produce small spatters around the parent stain as a result of striking a rough target surface. Spatter produced in this manner is referred to as satellite spatter or satellite stains. When multiple free-falling drops of blood are produced from a stationary source onto a horizontal surface, **drip patterns** will result from blood drops falling into previously deposited wet bloodstains or small pools of blood. These drip patterns will be large and irregular in shape, with small satellite spatters around the periphery of the central parent stain on the horizontal and nearby vertical surfaces (Figure 4.14). Satellite spatters are the result of smaller droplets of blood that have detached from the main blood volume at the moment of impact. These satellite spatters of blood are circular to oval in shape and usually have diameters ranging from 0.1 to 2.0 mm in size or slightly larger.

Several factors influence the appearance of satellite spatter, including the blood drop volume, freshness of blood, surface texture, and distance of the vertical target from the **impact site**. Rough surfaces, such as concrete, produce substantial satellite blood spatter from a single drop impact as well as from blood dripping into blood.

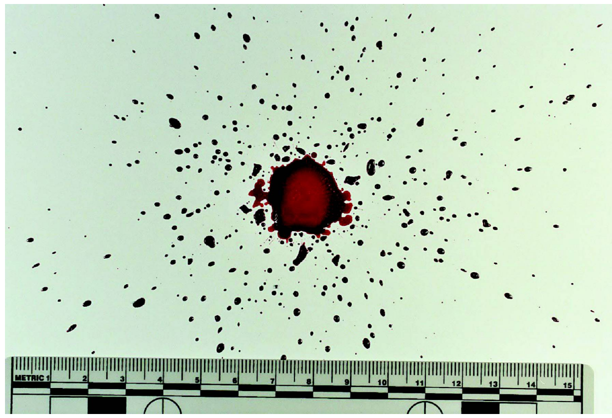

Figure 4.14 Drip pattern (blood dripping into blood) produced by single drops of blood falling 36 inches onto smooth cardboard. Note the extent of the satellite spatter around the parent or central stain.

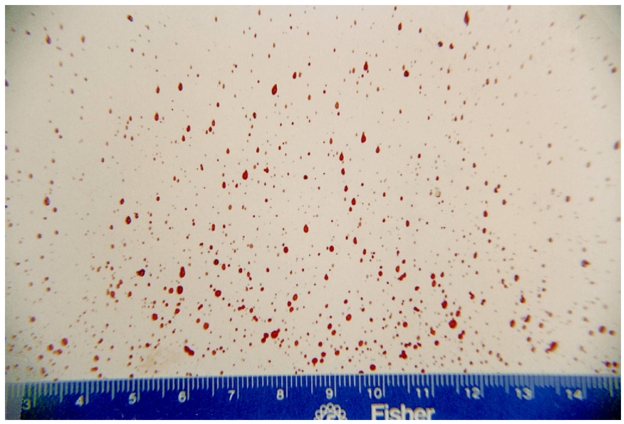

Figure 4.15 Satellite blood spatters produced on a vertical cardboard surface within 3 inches of blood dripping into blood on a concrete surface.

The vertical height achievable by the satellite spatter created with a single drop impacting concrete can be as high as 12 inches. Investigators often interpret small spatters of blood on suspects' trouser legs, socks, and shoes as impact blood spatter associated with a beating or shooting due to their small diameters (Figure 4.15). The mechanism of satellite blood spatter causing these stains should be thoroughly explored before reaching a final analysis and conclusion.

From a practical view, it is important that the investigator be able to recognize the types of bloodstains and patterns resulting from free-falling drops based on their size, shape, and distribution and then document their locations. These bloodstains should be categorized relative to the events that produced them, and they should be related to the possible sources and movement of these sources through the recognition of trails and drip patterns.

4.4.7 Castoff Bloodstain Patterns

During a beating with a blunt object, blood does not immediately accumulate at the impact site with the first blow. As a result, no blood is available to be spattered or cast from the first blow. Spatter and **castoff patterns** are created with subsequent blows to the same general area where a wound has occurred and blood has accumulated. Blood will adhere in varying quantities to the object that produces the

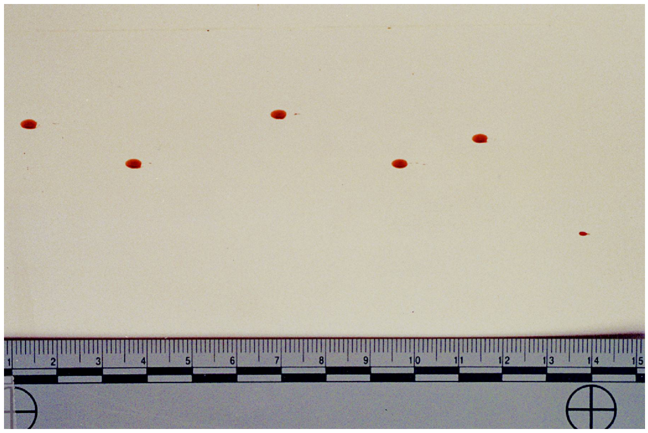

Figure 4.16 Linear distribution of castoff bloodstains on a vertical surface.

injuries. A centrifugal force is generated as an assailant swings the bloodied object. If the centrifugal force generated by swinging the weapon is great enough to overcome the adhesive force that holds the blood to the object, blood will be flung from the object and form a castoff bloodstain pattern.

The blood that is flung (castoff) will strike objects and surfaces, such as adjacent walls and ceilings in the vicinity, at the same angle from which it is flung or cast. The size, distribution, and quantity of these castoff bloodstains vary. Castoff bloodstain patterns may appear linear in distribution, and the individual stains are frequently larger in size than impact blood spatters (Figure 4.16). Castoff patterns are often seen in conjunction with impact spatters, and a study of each may help determine the relative position of the victim and the assailant at the time the injuries were inflicted. Castoff bloodstains are not always present at scenes where blunt or sharp force injuries have occurred. The arc of the back or side swing may be minimal, especially in the case of a heavy blunt object. Occasionally, analysts will attempt to determine whether the person swinging the object was right- or left-handed. This is dangerous, as many individuals may swing objects effectively with either hand. The analyst must also consider the possibility of back-handed swings that may appear similar. Also, it is not possible to determine with certainty the object that was being swung to create the castoff patterns based solely on the patterns.

4.4.8 Bloodstain Patterns Resulting from Large Volumes: Splashed and Projected Blood

When a quantity of blood in excess of 1.0 mL is subjected to minor force or is allowed to freely fall to a surface, a **splashed bloodstain pattern** will be produced. Splashed bloodstain patterns usually have large central areas with peripheral spatters appearing as elongated bloodstains. Secondary blood splashing or *ricochet* may occur as a result of the deflection from one surface to another of large volumes of blood after impact. When sufficient bleeding has occurred, splash patterns may be produced by the movement of the victim or assailant. These patterns are often created by large volumes of blood falling from a source such as a wound. Larger quantities of splashed blood will create more spatters. A **projected bloodstain pattern** is produced when blood is projected or released as the result of force exceeding that of gravity. When blood of sufficient volume is projected horizontally or downward with force exceeding the force of gravity, the resultant bloodstains exhibit numerous spine-like projections with narrow streaking of the secondary spatters compared

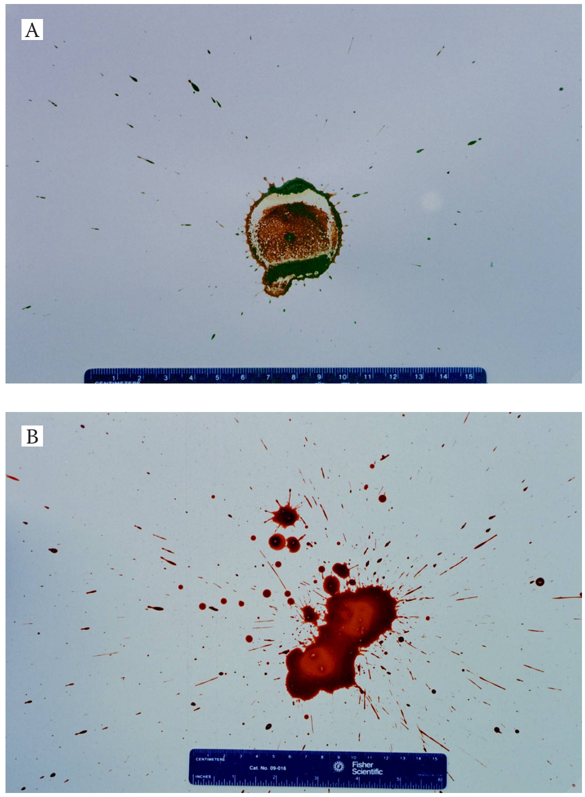

Figure 4.17 Bloodstain pattern produced by 1 mL of blood (A) falling downward 36 inches onto smooth cardboard and (B) projected downward 36 inches onto smooth cardboard.

with splashed bloodstains (Figure 4.17). Vomiting blood is an example of projected blood in a large volume. Blood may also be projected from a source or pool by rapid movement or by running through the pool.

4.4.9 Expirated Bloodstain Patterns

As a result of trauma, blood will often accumulate in the lungs, sinuses, and airway passages of the victim. In a living victim, this accumulation of blood will be forcefully expelled from the nose or mouth to free the airways. This type of bloodstain is referred to as an **expirated bloodstain pattern**. The size, shape, and distribution of an expirated bloodstain pattern are often similar to the patterns that are observed with impact spatter associated with beatings and gunshots (Figure 4.18). Because impact spatter due to a gunshot or beating mechanism can closely resemble expirated bloodstain patterns, the deciding factor may be the case history. An expiratory bloodstain pattern cannot possibly be produced unless the victim has blood on their face or in their mouth or nose, or has some type of injury to their chest or neck that involves the airways. Expirated bloodstains may appear diluted if mixed with sufficient saliva or nasal secretions. If the blood has been recently expelled there may be visible air bubbles within the stains due to the blood being mixed with air from the airway passages or lungs. When the bubbles rupture and the bloodstains dry, the areas of previous air bubbles will appear as **vacuoles**. In the absence of these vacuoles within the stains, this type of bloodstain pattern may be misinterpreted. Air bubbles or vacuoles and dilution are not always present in an expirated bloodstain pattern. The presence of air bubbles should be viewed as a presumptive indicator for expirated blood but not conclusive proof.

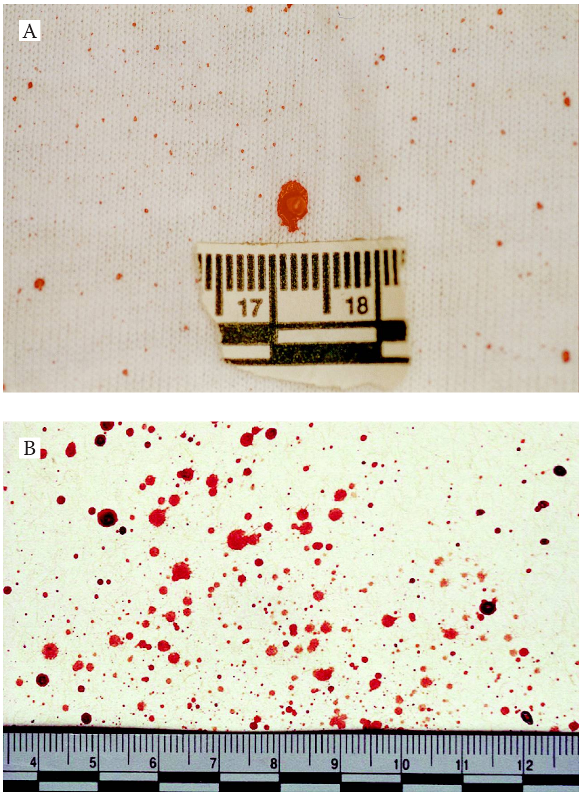

Figure 4.18 (A) Bloodstain pattern produced by exhalation of blood from the mouth onto cotton cloth with air bubble in stain pattern. (B) Pattern produced in a similar manner with no evidence of air bubbles or vacuoles. In their absence, the pattern is similar to those produced by beating or shooting mechanisms.

4.4.10 Arterial Bloodstain Patterns

When an artery is breached, blood is projected from it in varying amounts. The size of arterial bloodstains varies from very large gushing or spurting patterns to very small spray types of patterns (Figure 4.19). The type of arterial pattern observed is a function of the severity of the injury to the artery, the size and location of the artery, whether the injury is covered by clothing, and the position of the victim when the injury was inflicted. Obviously, arterial bloodstaining is accompanied by demonstrable arterial damage. The bloodstain pattern analyst should verify his or her hypothesis about an arterial bloodstain pattern by reviewing the autopsy report or speaking directly with the forensic pathologist who conducted the autopsy. These patterns are usually very distinctive due to the overall quantity of bloodstains observed.

4.4.11 Transfer Bloodstain Patterns

When an object wet with blood comes into contact with an object or secondary surface, a blood **transfer pattern** occurs. These patterns may assist an examiner in determining the object that made the pattern (e.g., hair, knife, shoe), because a recognizable mirror image of the original surface or a portion of that surface may be produced (Figure 4.20). When attempting to determine whether an object could have produced a particular transfer pattern, it is usually necessary to conduct a series of experiments using items similar to those in question, as it is never good

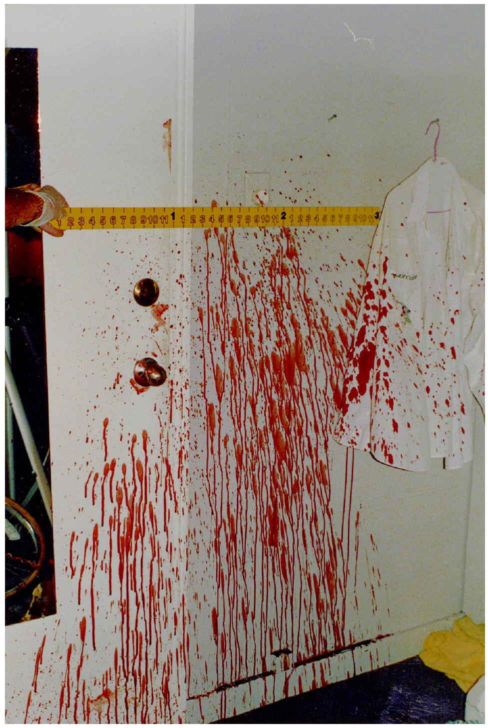

Figure 4.19 Arterial spurt pattern produced by victim who sustained a severed right carotid artery.

practice to add blood to an evidentiary object. Class or individual characteristics may be determined from distinct blood transfer patterns, such as finger and palm prints or foot and footwear impressions (Figure 4.21). Partial bloody impressions are often chemically enhanced to resolve additional detail.

The differentiation between a minute transfer pattern and an impact spatter pattern on a suspect's clothing may determine whether he or she could have been the perpetrator or merely someone who came into contact with the blood source. If spatter is identified on a garment, that generally means that the wearer of the garment was in the immediate vicinity of the bloodshed event (e.g., beating, shooting). The determination of whether the bloodstains on garments are the results of spatter or transfer is not always easy and often requires experimentation and microscopic examination of the garments.

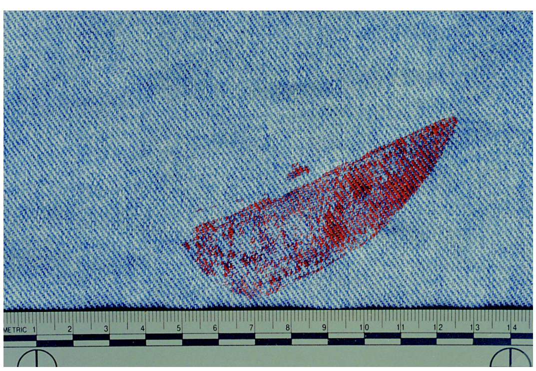

Figure 4.20 Transfer pattern on denim produced by contact with a knife blade containing wet blood.

Figure 4.21 Partial fingerprint produced by contact of a finger containing wet blood with smooth cardboard.

4.5 Altered Bloodstains

Bloodstains deposited on surfaces at a scene are subject to various forms of change from their original appearance at the time the bloodshedding event occurred. Recognition of these alterations and an understanding of their significance are important for the reconstruction of the event. When blood exits the body, the processes of drying and clotting are initiated. The drying time of blood is a function of its volume, the nature of the target surface texture, and the environmental conditions. Small spatters and light transfers of blood will dry within a few minutes under normal conditions of temperature, humidity, and air currents. Larger volumes of blood may take considerable time to completely dry. Drying is accelerated by increased temperature, low humidity, and increased airflow. Initially, the outer rim or perimeter of the bloodstain will show evidence of drying, which then proceeds toward the central portion of the stained area.

When the center of a dried bloodstain flakes away and leaves a visible outer rim, the result is referred to as a **skeletonized bloodstain** (Figure 4.22A). Another type of skeletonized bloodstain occurs when the central area of a partially dried bloodstain is altered by contact or a wiping motion that leaves the periphery intact (Figure 4.22B). This can be interpreted as movement or activity by the victim or assailant when or after injuries were inflicted.

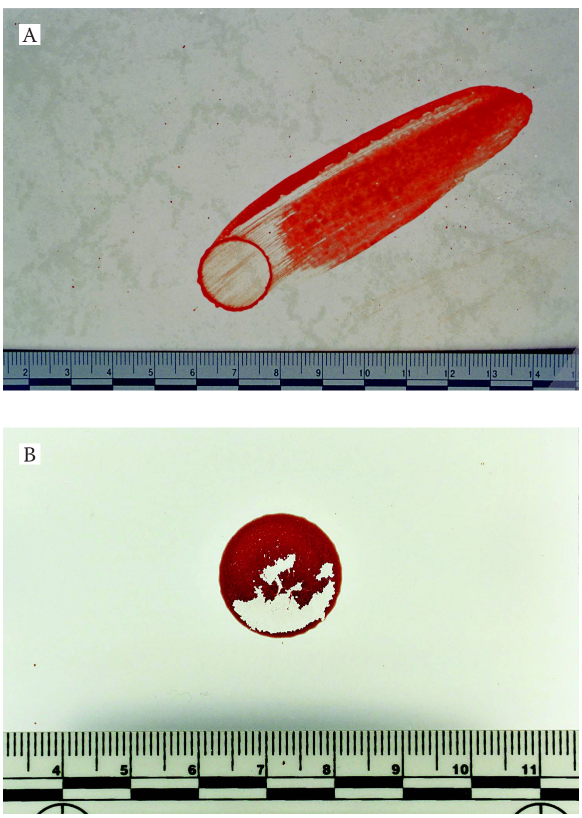

Figure 4.22 (A) Skeletonized bloodstain created by drying and flaking away of the central area of the stain. (B) Skeletonized bloodstain produced by a wiping alteration of a partially dried bloodstain, indicating activity shortly after the blood was deposited. Note the remaining peripheral ring of the original bloodstain caused by drying around the edges.

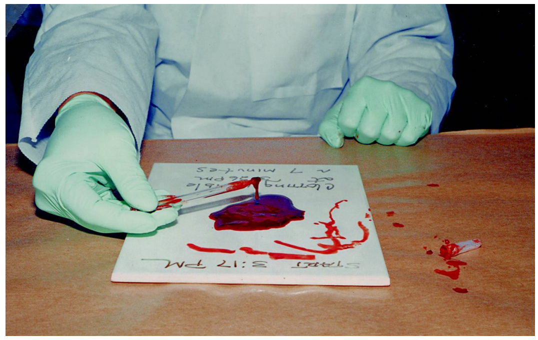

Figure 4.23 Demonstration of clot formation in freshly drawn human blood after 7 minutes.

As dried bloodstains age, they tend to progress through a series of color changes from red to reddish brown and eventually to black. The estimation of the age of bloodstains based on color is difficult because environmental conditions and the presence of bacteria and other microorganisms affect the sequence and duration of color changes. Any estimate of time lapse should involve experiments utilizing freshly drawn human blood of similar volume placed onto a similar surface with environmental conditions duplicated as closely as possible.

The clotting process is also initiated when blood exits the body and is exposed to a foreign surface. The appearance and extent of clotted blood at a scene may provide an indication of the amount of time elapsed since the injury occurred. Normal clotting time of blood that has exited the body ranges from 3 to 15 minutes in healthy individuals (Figure 4.23). As a clot progressively forms a jellylike mass, it retracts and forces the serum out of and away from the progressively stabilizing clot. Occasionally a bloodstain analyst will observe clotted impact spatters on clothing or other surfaces (Figure 4.24). Clots of blood may show drag patterns that indicate that additional activity, such as movement or further injury, occurred after a significant interval had elapsed from the initial bloodshed. Evidence of coughing or exhalation of clotted blood by a victim may be associated with post-injury survival time. Existing wet bloodstains at a scene are also subject to alteration in appearance due to smudging, smearing, and wiping activities of the victim or assailant. Changes in the appearance of bloodstains and patterns and additional bloodstains may also be created by paramedical treatment of the victim or removal of the victim from the scene.

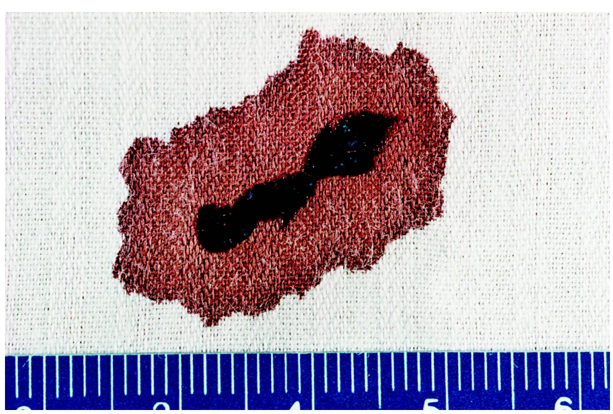

Figure 4.24 Clotted spatter on fabric exhibiting dark central area with lighter peripheral area of the stain.

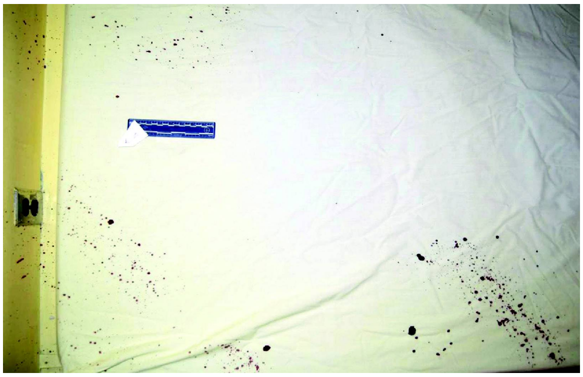

Figure 4.25 Void area, seen where items have been removed from an area spattered with blood.

Another source of bloodstain alteration is moisture, such as rain or snow, which will dilute existing bloodstains at a scene exposed to the outside environment. Investigators may also encounter indoor scenes and vehicles that have been cleaned with water and detergents or that have been painted after a bloodshed event. Diluted bloodstains may be difficult or impossible to locate without the use of a chemical enhancement process such as luminol treatment. The alteration of bloodstains by heat, fire, or smoke may also cause problems for the analyst. Bloodstains covered with soot may be entirely missed at the scene of a homicide that preceded a fire. Heat and fire may also cause existing bloodstains to fade, darken, or be completely destroyed.

Void areas or patterns are absences of bloodstains in otherwise continuous patterns of staining (Figure 4.25). These patterns are commonly seen where items have been removed from an area previously spattered with blood. This permits the analyst to establish sequencing and identify alterations within a crime scene. At a scene containing a considerable amount of spattered blood, the void areas may be utilized to recognize the general location where the spatter-producing event occurred.

4.6 Analysis of Bloodstains on Clothing and Footwear

The clothing of a suspect is often a critical piece of evidence that can help link the suspect to the incident through the bloodstain patterns present on his or her garments. Generally, two questions arise with bloodstained garments: (1) Whose blood is on the garment? and (2) How was the blood deposited onto the garment? With advances in DNA technology, the determination of whose blood is on clothing is normally not a problem. The bloodstain pattern analyst determines how the blood was deposited onto the garments. Generally, the deposition of blood onto garments falls into one or both of the following categories:

- *Passive bloodstaining*, including transfer, **flow patterns**, **saturation stains**, and stains resulting from dripping blood
- *Active bloodstaining*, including impact spatter, arterial spurts, expirated bloodstains, castoff, etc.

It is necessary to identify and document the specific patterns prior to attaching any case-related significance to the patterns. Before drawing conclusions from bloodstain patterns on clothing or any other medium, an analyst should request and review any available DNA results.

The analysis of bloodstain patterns on clothing often centers on substantiating or refuting the suspect's version of how his or her clothing became stained with blood. A common example is where a suspect claims to have come into contact with the victim only after the injuries had been inflicted; that is, the suspect was not present when the assault occurred. In such instances, determination of the mechanism of stain creation may have more evidentiary value than identifying the source of the blood. If the bloodstains have transfer patterns in which the blood is deposited on top of the weave of the fabric, then the analyst may substantiate the suspect's claims. If dozens of small spatters of blood are embedded within the fibers of the garment, then the bloodstain evidence refutes the suspect's version of events.

The analysis of bloodstains on clothing can be difficult and often requires experimentation and extensive experience. It has been the authors' experience that bloodstain patterns on textiles are unpredictable due to their varying compositions and textures. For this reason, one should be cautious when interpreting bloodstain patterns on garments. To facilitate the examination of clothing by a bloodstain analyst, the following steps should be taken:

- Establish the manner in which the garments were collected, documented, and preserved prior to their examination.
- Document the garments while the victim or suspect is still wearing them, when possible.
- Allow the bloodstain analyst an opportunity to examine the stains before their removal for DNA analysis. The amount of bloodstaining is usually limited, and the geometry of the stains should be examined before they are consumed in serological analysis. The geometric analysis of bloodstain patterns is a nondestructive examination.
- Take photographs and, if needed, photomicrographs before sample cuttings of stains are removed.
- Obtain a history of where the garment has been and how it has been handled. An example would be a shirt collected from the emergency room floor after a suspect's injuries were treated. The significance of the bloodstain patterns on this shirt could have been compromised, because additional bloodstains may have been deposited on the shirt or existing bloodstains may have been altered.

4.7 Documentation of Bloodstain Evidence

Because by definition bloodstains of forensic interest occur at a location that is definable as a crime scene, the same considerations as discussed in the previous chapter apply (for an example, see Case Study 4.1). In addition, when documenting bloodstain patterns, attention should be given to the following points:

- Accurately document the size, shape, and distribution of the individual stains and the overall patterns.
- Include measuring devices within the photographs.
- Use more than one mechanism for documentation (i.e., photographs, notes, diagrams, and video). This overlap should prevent anything of significance from being overlooked.

- If possible, collect articles of evidence that may contain significant or questionable bloodstain patterns.
- Utilize overall, mid-range, and close-up macrophotography when documenting bloodstain patterns. Photographs should overlap so that close-up photographs can be associated with their location within the pattern. Microphotography is also a useful technique to study small spatters. Bloodstain pattern analysis is very visual, and high-quality photographs make it easy to illustrate the significance of bloodstain patterns to a jury.
- Complete the documentation in such a manner as to allow a third party to utilize the photographs, notes, diagrams, and video to place the bloodstain patterns and articles of evidence back in their original locations.

4.8 Absence of Evidence Is Not Evidence of Absence

In many cases, the presence of bloodstains originating from the victim and found on the clothing or person of a suspect is powerful evidence to link the suspect to the violent act. It must be pointed out that the absence of blood spatter on a suspect or his clothing does not preclude his or her active participation in a bloodshed event. It is possible to beat, stab, or shoot someone without being spattered with blood, and exceptions to this rule are few. Unfortunately, many defense attorneys attempt to offer the absence of blood spatter on their clients as proof of lack of participation. From a review of the scientific literature and from practical experience, it is not uncommon for an assailant to have little if any blood on his or her person after committing a violent crime. The absence of bloodstaining on an active participant in a bloodshed event has several explanations:

- The directionality of the blows with a blunt object or thrusts with a knife may direct spatters of blood away from the assailant.
- If the site of the injury is covered with clothing or other material during the assault, the amount of spatter may be greatly reduced or absent.
- The assailant may have cleaned up or changed clothing prior to being apprehended.
- The assailant may have worn protective outerwear.
- The assailant may have removed his clothing prior to committing the assault.
- The amount of blood present at a scene described as "covered in blood" or a "bloodbath" may be primarily due to active bleeding from a victim who is still alive or from the draining of blood from wounds of a deceased individual that occurred after the assailant left the scene.
- Individuals have been known to confess to crimes that they, in fact, did not commit.

It is important to recognize that conclusions in bloodstain pattern analysis should not be based on bloodstains or spatter that the analyst would expect to be present, but rather on bloodstains or spatter that are physically present. In most cases, the absence of bloodstains on the clothing of a suspect should neither exonerate nor implicate his or her involvement in a violent act.

CASE STUDY 4.1: AN INTEGRATED EXAMPLE

Police responded to a single-family residence. Upon arrival, they were met at the front door by the victim's husband, who indicated that his wife had shot herself. Blood was observed on the husband's clothing. The victim was located lying on the bed in the master bedroom. She was clad in pajamas and was partially covered with blankets. The victim had sustained a single gunshot wound to the right side of her head. A Sig Sauer, P226, 9-mm pistol was located on the nightstand adjacent to the bed, the clip had been removed and the slide was locked open. The husband acknowledged removing the clip and clearing the pistol and placing it on the night stand; he also indicated he washed blood off his hands and face in the bathroom, although he denied any involvement in the death of his wife. The victim died as a result of a single close-contact gunshot wound to the right side of her face, just anterior to the right ear. The projectile did not exit her body.

Figure CS4.1.1 depicts the overall location of the body of the victim in the master bedroom bed. A light blue blanket and a white quilted comforter can be seen on the lower half of the bed. Several pillows are located around the victim's head and torso. The east wall of the master bedroom and the entrance to the bedroom are located in the background. A nightstand is located along the east wall between the bed and doorway. A Sig Sauer, P226, 9-mm pistol was located on top of this nightstand. The slide of the pistol was locked open and the clip had been removed from the pistol. The pistol, the clip, and a live round of ammunition were all on the nightstand. Transfer-type bloodstains were located on the majority of the pistol. Bloodstains were present on the exterior of the clip. A dresser with a mirrored top is located on the south wall located to the right of the bed.

Figure CS4.1.2 is a mid-range photograph of the victim's final position after the pillows and blankets were removed. The left arm of the victim was noted to be folded back beneath her torso. A large saturation pattern was located on the fitted sheet adjacent to the victim's left side. This saturation pattern along with the positioning of her right arm is consistent with the victim being on or over this area while bleeding heavily prior to her final position.

Three distinct bloodstain patterns are visible on the east wall, as shown in Figure CS4.1.3. A large saturation pattern is located on the fitted sheet. A number of spatters are present on the fitted sheet to the right of this saturation

Figure CS4.1.1 Overall location of the victim in the master bedroom.

Figure CS4.1.2 View of the victim's final position after the pillows and blankets were removed.

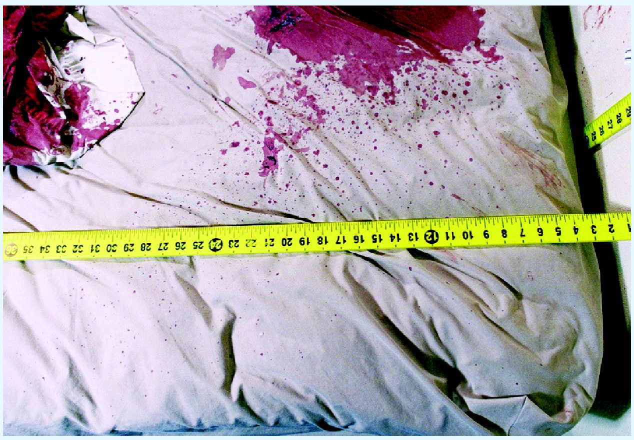

Figure CS4.1.3 Closer view of the spatter distribution on the bed observed in Stain Area D of Figure CS4.1.2.

pattern. Figure CS4.1.3 provides a closer view of the spatter distribution on the bed. The physical appearance, location, and distribution of these spatters are consistent with there being back spatter emanating from the victim's entrance gunshot wound. Figure CS4.1.4 shows the overall appearance of stain patterns on the east bedroom wall. This stain pattern consists of a linear distribution

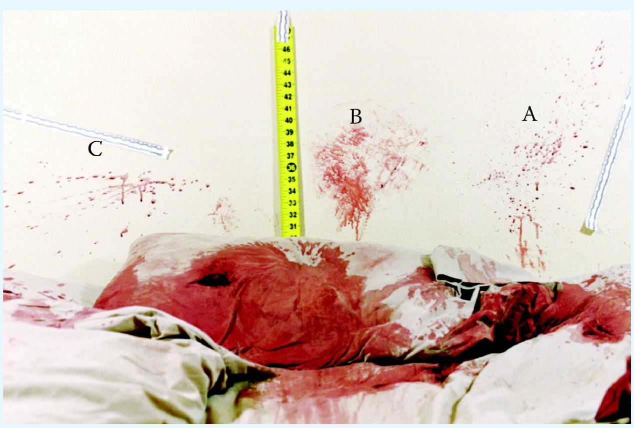

Figure CS4.1.4 View of overall appearance of stain patterns A to C on the east bedroom wall.

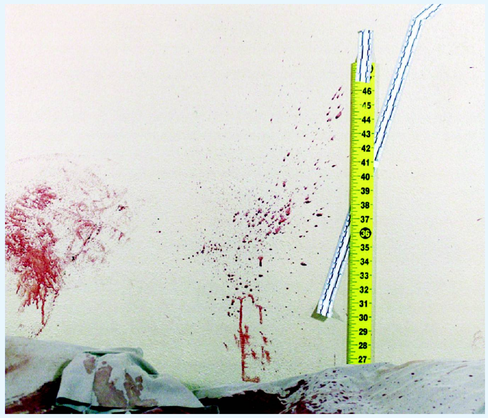

Figure CS4.1.5 View of stain area A on the east bedroom wall.

of larger spatters, whose direction of travel is right to left and downward. The physical appearance and distribution of these spatters are consistent with their being produced by a projection mechanism secondary to the shooting.

The physical appearance of these bloodstain patterns is consistent with their being transfer bloodstain patterns. These transfer patterns were created, secondary to the shooting, when an object wet with blood came into direct contact with this portion of the wall. The physical appearance and distribution of the individual stains composing the spatter pattern on the right in Figure CS4.1.4 are consistent with there being back spatter associated with the victim's entrance gunshot wound. The direction of travel of the spatters is left to right and upward (Figure CS4.1.5). When a bullet strikes a blood source, the spatter that emanates from the entrance wound is back spatter.

The direction of travel of the spatters is left to right and upward. Representative spatters from this pattern were selected and utilized to establish an area of convergence. Figure CS4.1.6 illustrates the area of convergence of the back spatter pattern on the east wall of the master bedroom. The area of convergence was located at approximately 35 inches from the floor and 64.5 inches from the southeast corner of the bedroom. The black line located below the area

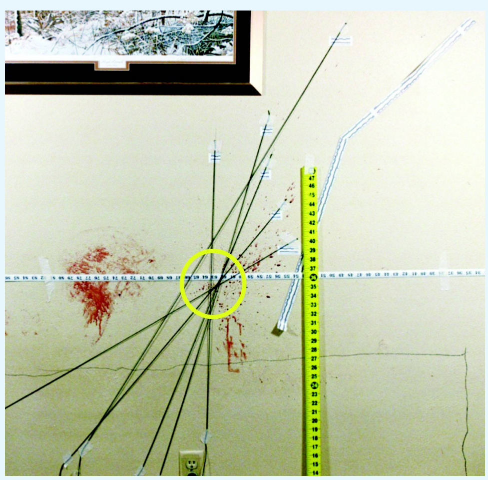

Figure CS4.1.6 View of area of convergence of back spatter pattern on the east bedroom wall.

Figure CS4.1.7 View of bedroom from the doorway of the master bedroom across the bed.

of convergence in Figure CS4.1.6 depicts the location of the bed along the east wall prior to its removal. The uncompressed mattress height was determined to be between 26 and 28 inches This indicates that the victim's entrance gunshot wound was located approximately 7 to 9 inches above the mattress when her wound was inflicted. This would place the left side of her head close to if not in contact with the mattress and/or pillow when the shot was fired.

Figure CS4.1.7 provides a view of the bedroom from the doorway of the master bedroom across the bed toward the mirror-topped dresser, located along the south bedroom wall. In addition, the overall location of the back spatter patterns located on the fitted sheet and on the east wall can be observed. Spatters were observed on both the right and left side front drawer areas of the dresser. The centermost area of the dresser was void of any blood spatters. The large yellow arrows on the dresser represent the distribution of spatters on the front of the dresser. Samples were collected from both sides of the front of the dresser. The spatters on the protruding drawer front areas of the dresser are consistent with back spatter from the victim's entrance gunshot wound.

Figure CS4.1.8 depicts a series of bloodstains on the bathroom floor. These passive bloodstains are consistent with a blood source moving across the bathroom floor while dripping blood. Some of these bloodstains exhibited a diluted appearance. Figure CS4.1.9 shows the diluted bloodstains located on the bathroom sink counter as well as within the sink basin. A bloodstained tissue/paper product was located on top of the counter. Figure CS4.1.10 shows the diluted bloodstains that were located within the kitchen sink as well as on the kitchen counter adjacent to the kitchen sink. A light blue plastic cup was also located on the counter adjacent to the kitchen sink. This cup also had diluted bloodstains present on its exterior surface.

Photographs taken of the victim's husband on the day of the incident documented spatter on the right side of his face, cheek, and around his right eye. The husband was clad in a gray sleeveless T-shirt. The front of the husband's gray T-shirt can be seen in Figure CS4.1.11. A distribution of small spatters is located over the front of both shoulders and over the top of the right shoulder area. A number of these spatters were encircled on the garment with a black

Figure CS4.1.8 View of passive bloodstains on the bathroom floor.

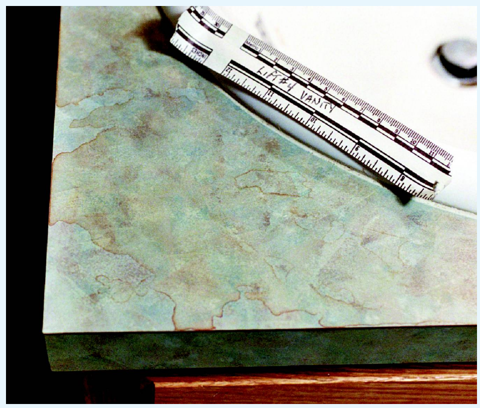

Figure CS4.1.9 View of diluted bloodstains located on the bathroom sink counter as well as within the sink basin.

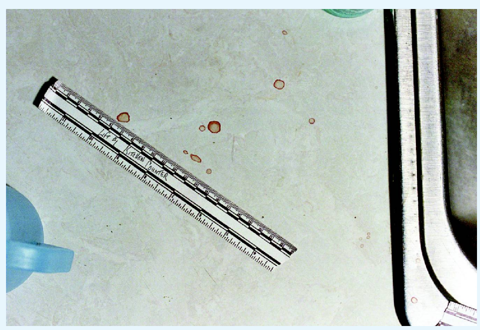

Figure CS4.1.10 View of the diluted bloodstains located within the kitchen sink and on the kitchen counter adjacent to the kitchen sink.

marker to illustrate the distribution of the spatters. Two transfer patterns are centrally located on the T-shirt, with the higher and more dense pattern located 19 to 25 inches from the bottom hem. The lower less dense pattern was located 12.5 to 16 inches from the bottom hem. Additional spatters of blood were observed over the mid-section of the T-shirt.

Figure CS4.1.11 View of the front of the husband's gray T-shirt.

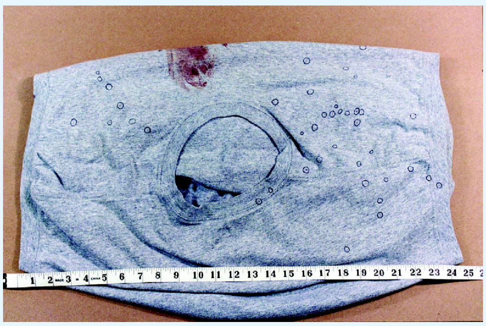

Figure CS4.1.12 View of the gray T-shirt from the top down.

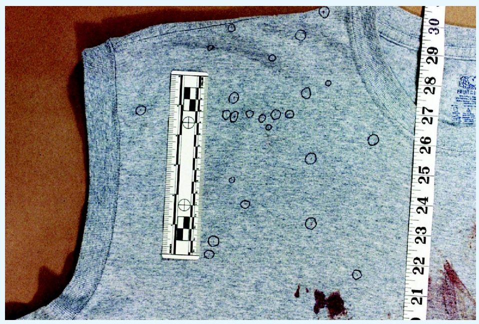

Figure CS4.1.13 View of spatters located on the upper right shoulder region of the gray T-shirt.

Figure CS4.1.12 provides a view of the T-shirt from the top down that illustrates the distribution of spatters on the upper front of the T-shirt as well as on the back and top of the right shoulder region. Figure CS4.1.13 illustrates the location and physical appearance of the spatters located on the upper right shoulder region of the T-shirt. The physical appearance and distribution of spatters on this T-shirt are consistent with their being the result of back spatter from the victim's entrance gunshot wound. Figure CS4.1.14 provides a closer view of the transfer pattern located on the upper front chest region of the T-shirt in Figure CS4.1.12. Clot-like material is located within this transfer pattern.

INTERPRETATION OF THE EVIDENCE

The husband gave several versions as to where he was located when the shot occurred, none of which placed him on the south side of the bed in front of the dresser; however, the bloodstain pattern evidence provided enough information to determine what could and could not have happened. The distribution of

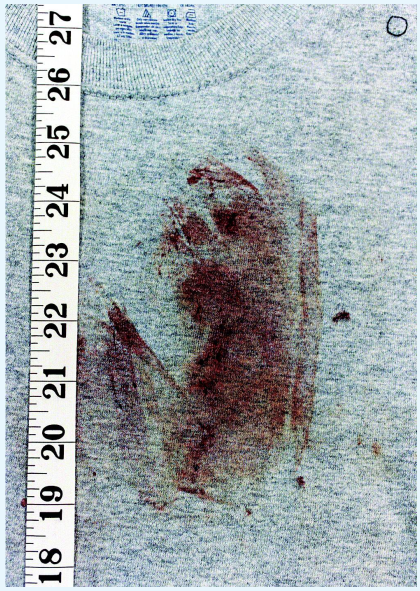

Figure CS4.1.14 Closer view of the transfer pattern located on the upper front chest region of the gray T-shirt.

spatter on the east bedroom wall, the positioning of the victim's left arm under her body, and the larger saturation pattern on the fitted sheet adjacent to her left shoulder, as well as the distribution of spatter on the fitted sheet adjacent to the large saturation pattern, indicate that the victim's body was rolled or moved over to her final resting position after her gunshot wound had been inflicted.

The bloodstain patterns and forensic evidence of this case are consistent with the victim lying in bed on her stomach with the left side of her face against the bed. The bloodstain evidence in the bathroom and kitchen is consistent with an individual, other than the victim, attempting to clean up a source of the victim's blood from their person and/or objects in their possession. The clot-like material within the transfer pattern on the front of the husband's T-shirt indicates that the victim's blood had begun clotting prior to the T-shirt making contact with her blood. The physical appearance and distribution of the spatters on the upper front shoulder region and back right shoulder region of the husband's T-shirt are consistent with back spatter associated with gunshot. This back spatter associated with gunshot is consistent with spatter emanating from the entrance gunshot wound to the head of the victim.

The physical appearance and distribution of back spatter on the husband's T-shirt indicate that he was in close proximity to the victim's head when her gunshot wound was inflicted. This is further supported by the location and distribution of stains on the right side of the husband's face. The physical evidence is consistent with the husband being on the south side of the bed between the bed and dresser when the victim was shot in the right side of the head. Furthermore, the bloodstain pattern evidence at the scene as well as on the husband's person placed him within the void area of the dresser on the south side of the bed when his wife's injury was inflicted.

The husband ultimately went to trial and was found guilty of murder.

4.9 Scientific Working Group on Bloodstain Pattern Analysis: Recommended Terminology

4.9.1 Introduction

The Scientific Working Group on Bloodstain Pattern Analysis (SWGSTAIN) is comprised of bloodstain pattern analysis (BPA) experts from North America, Europe, New Zealand, and Australia. SWGSTAIN serves as a professional forum in which practitioners in BPA and related fields can discuss and evaluate methods, techniques, protocols, quality assurance, education, and research. The ultimate goal of SWGSTAIN is to use these professional exchanges to address substantive and operational issues within the field of BPA and to build consensus-based, or "best practice," guidelines for enhancement of the discipline of BPA. This section provides a recommended list of terms to utilize when teaching, discussing, writing, or testifying on bloodstain pattern analysis. In developing this list, SWGSTAIN reviewed terminology in use across the field of bloodstain pattern analysis.

4.9.2 Terminology

Accompanying drop: A small blood drop produced as a byproduct of drop formation.

Altered bloodstain: A bloodstain or pattern with characteristics that indicate a physical change has occurred.

Angle of impact: The acute angle at which a blood drop strikes a target, relative to the plane of the target.

Area of convergence: The area of intersection in two dimensions created by lines drawn through the long axis of individual stains, most often associated with an impact pattern.

Area of origin: The area in three dimensions of a blood source most often associated with an impact pattern.

Back spatter pattern: A bloodstain pattern resulting from blood drops that travel in the opposite direction of the external force applied. Back spatter is often associated with a gunshot entrance wound.

Blood clot: A gelatinous mass formed by a complex mechanism involving red cells, fibrinogen, platelets, and other clotting factors.

Bloodstain: A spot or stain made by blood.

Bloodstain pattern: A characteristic grouping or distribution of bloodstains which may indicate the manner in which the pattern was deposited.

Bubble ring: A ring in a bloodstain that results from an air bubble.

Castoff pattern: A bloodstain pattern resulting from blood drops released from a bloodied object in motion.

Cessation castoff pattern: A bloodstain pattern resulting from blood drops released from a bloody object as it suddenly stops.

Directionality: The path of travel of a blood drop indicated by the stain's shape.

Directional angle: The angle between the long axis of a bloodstain and a reference line on the target.

Drip pattern: A bloodstain pattern resulting from liquid dripping into liquid, where at least one liquid is blood.

Drip stain: A bloodstain resulting from the formation and falling of a drop of blood.

Drip trail: A series of bloodstains resulting from blood dripping from a source that is in horizontal motion.

Edge characteristic: The physical characteristics at the periphery of a bloodstain that may be described as spines, scalloping, smooth, or irregular margins.

Expirated pattern: A bloodstain pattern resulting from blood being forced out of the nose, mouth, or a wound by air pressure.

Flow pattern: A bloodstain pattern resulting from the movement of a volume of blood on a surface due to gravity and/or movement of the target.

Forward spatter pattern: A bloodstain pattern resulting from blood drops that travel in the same direction as the external force applied. Forward spatter is often associated with an exit gunshot wound.

Impact pattern: A bloodstain pattern resulting from an object striking liquid blood.

Insect stain: Bloodstains produced as the result of insect activity.

Mist pattern: A bloodstain pattern resulting from blood reduced to a spray of localized micro drops as a result of the force applied, often associated with gunshot injuries.

Parent stain: The bloodstain from which wave castoff or satellite bloodstains originate.

Pool: An accumulation of liquid blood on a surface.

Projected pattern: A bloodstain pattern resulting from the ejection of a volume of blood under pressure, often associated with a vascular breach.

Satellite stain: Smaller bloodstains that originate during the formation of the parent stain as a result of blood impacting a surface.

Saturation pattern: A bloodstain resulting from the accumulation of liquid blood in an absorbent material.

Serum stain: The stain resulting from the liquid portion of blood that separates after coagulation.

Skeletonized stain: A bloodstain that has been altered after a period of drying, leaving observable peripheral characteristics of the original stain.

Spatter stains: Bloodstains resulting from blood drops distributed through the air due to an external force applied to a source of liquid blood.

Splash pattern: A bloodstain pattern resulting from a volume of liquid blood that falls or spills onto a surface.

Swipe pattern: A bloodstain pattern resulting from the transfer of blood from a bloodied surface onto another surface, with characteristics that indicate relative motion between the two surfaces.

Target: A surface onto which blood has been deposited.

Transfer pattern: A bloodstain pattern resulting from contact between a wet bloody surface and another surface.

Void: The absence of blood in an otherwise continuous bloodstain pattern.

Wave castoff stain: A satellite bloodstain that originates from a parent bloodstain due to the wave-like action of the liquid that occurs when the parent drop strikes a surface at an angle.

Wipe pattern: A bloodstain pattern resulting from an object moving through a preexisting bloodstain, altering the original stain.

Chapter Summary

Bloodstain patterns are found at most violent crime scenes. As with any type of crime scene evidence, they must be found, documented, analyzed, and interpreted. Scientific analysis of bloodstain patterns is invaluable for determining what could have happened and what could not have happened to create the observed pattern. Bloodstain pattern analysis has a long history (by forensic science standards), dating back into the 1800s, and it continues to be a critical aspect of crime scene analysis and interpretation. This chapter concludes our study of forensic science as applied to crime scene analysis and processing. In the next section, we will learn about death investigation. Although not all deaths are crimes, many require at least some degree of forensic investigation. As you read through this section, you will see how vital proper crime scene investigation is in cases of homicide or suspicious death.

4.10 Review Material

4.10.1 Key Terms and Concepts

Angle of impact
Area of convergence
Area of origin
Back spatter
Bloodstain pattern analysis
Castoff patterns
Directionality
Drip patterns
Erythrocytes
Expirated bloodstain patterns
Exsanguination
Flow patterns
Forward spatter
IABPA
Impact site
Leukocytes
Misting
Plasma
Platelets
Projected bloodstain pattern
RBCs
Satellite spatter
Saturation stains
Serum
Skeletonized bloodstain
Specific gravity
Splashed bloodstain pattern
SWGSTAIN
Surface tension
Terminal velocity
Transfer pattern
Vacuoles
Viscosity
Void areas
WBCs

4.10.2 Questions

1. What significant physical properties of blood determine the shape of a blood drop in flight?
2. What is the most important factor governing the degree of distortion and amount of spatter created when a blood drop strikes a surface?
3. What factors influence the stain diameter produced by a free-falling drop?
4. How are the physical characteristics of spatter utilized to determine their angle of impact?
5. Compare the size ranges of the spatters in the following scenarios: (1) spatter associated with a beating, (2) spatter associated with a gunshot, and (3) expirated blood.
6. What other mechanisms can create spatters in the same size range as impact spatter encountered in beating, stabbing, and gunshot events?
7. What variables can affect the size, quantity, and distribution of spatters created by an impact mechanism such as beatings and shootings?
8. Discuss the techniques employed for determining the area of convergence and origin of bloodstain pattern.

9. Name two types of bloodstain patterns that require confirmation by autopsy findings.
10. Explain why an assailant might not have any bloodstains on his or her person or clothing after participating in a beating death.
11. Explain the mechanism of castoff bloodstain patterns.
12. What are the features of progressive drying and clotting of blood?
13. How can bloodstains be physically altered at crime scenes?
14. What important information can be derived from the examination of bloodstain patterns?
15. What methods are commonly used to document bloodstain evidence?

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