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Observations of High Velocity Bloodspatter on Adjacent Objects

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ABSTRACT: In a recent homicide investigation, high velocity backspatter was observed on the sleeve cuff of the accused. These minute droplets were discovered only after microscopic examination and were limited in number. A study was initiated to determine if these were truly backspatter droplets or transferred blood produced from light contact with a bloody item. It was observed that the backspattered blood was primarily limited to contact or near contact shots. An exception was a shot into an already bloody surface. It was found that backspattered blood would deposit on the shooter's shirt sleeve irrespective of the weave pattern. Transferred blood was observed only on the fiber tops. This information was found to be useful in reconstruction of events in suicides as well as possible homicides.

KEYWORDS: criminalistics, ballistics, blood, drops (liquids), wound ballistics, bloodspatter, backspatter, homicide

The interpretation of bloodspatter by the Oregon State Police Crime Laboratory Division has been a useful technique in crime scene investigations for many years. Most commonly it is observed on floors, walls, and ceilings and can be prima facie evidence in the reconstruction of events. Proper interpretation of this crime scene evidence is invaluable to the detective division not only in reconstruction of previous events, but in the timeliness of the interpretation. Much information can often be provided while at the crime scene or before suspect and witness interviews or both.

Bloodspatter has been divided into three categories: low, medium, and high velocity. Low velocity is defined as blood which falls only by the force of gravity. Someone losing blood from a bloody nose is an example. Medium velocity bloodspatter is smaller in diameter and has the additional energy caused by the movement of an instrument or appendage. Blood departing from a fist striking a bloody nose is medium velocity. High velocity bloodspatter is created by the discharge of a firearm [1]. Sufficient energy is transferred to a wound or bloody surface that an aerosol or mist of fine droplets is effected. The original direction and the three-dimensional origin may be determined from length and width measurements of selected droplets in all three categories. These principles have been explored and verified by several authors [2-8].

Bloodspatter on clothing may be sometimes overlooked in favor of blood-typing tests. Although these patterns are often small, they may have a story to tell. Medium velocity spatter

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on a pair of tennis shoes may put a perpetrator at a crime scene during a beating, as opposed to passing by after the victim was already dead.

High velocity bloodspatters from a single gunshot would appear to be the result of kinetic energy transfer from the hot gases entering the wound after the projectile and expanding the surrounding tissue. This expansion and subsequent contraction creates secondary projectiles (a bloody aerosol) traveling back toward the weapon and the supporting hand. Many of these droplets are less than 1 mm in diameter. Their flight is limited due to their high-surface-area-to-mass ratio and consequently are often found on nearby objects. The quantity observed will be dependent upon the muzzle-to-target geometry and the proximity of the impacted surface.

Actual case observations indicate an exposed skin area, such as the forehead or the hand, will create considerably more backspatter than a cloth or hair covered area. The exception is in multiple shot situations, where blood has pooled onto the cloth surface or saturated the head hair. A follow-up shot here also produces a large quantity of backspatter.

Much of the experimentation described herein was the result of two recent case investigations in which it was possible to establish, in the absence of a firearm, that the accused was linked to the shootings based upon microscopic examination of the subject's clothing, physical evidence, and information derived from the victim. This included microscopic and chemical proximity tests on the victim's clothing and also wound observations at the autopsy. Experiments were conducted to compare this evidence against transferred blood, such as light contact with another bloody item. The amount of spatter, size and shape of the droplets, its location on cloth weave, and its general position on the suspect's sleeve were considered and found to correlate with a contact or near contact shot to the victims.

Experimental Procedure

Simulated gunshot wounds were produced with a Ruger Mark IV .22 rimfire revolver held horizontal to the target. A blood soaked sponge was placed inside a plastic bag, sealed, and pinned vertically to the front of a pea-gravel bullet trap. Test fires were performed in contact, near contact, and muzzle-to-target distances as far back as 1 ft (0.3 m). Similar tests were performed after the sponge bag was covered with varying layers of cloth (Figs. 1 and 2).



FIG. 1—Strobe photography using a sound trigger captured the weapon recoil and the subsequent bloodspatter. Those droplets exhibiting a teardrop shape have already struck the paper behind the target.

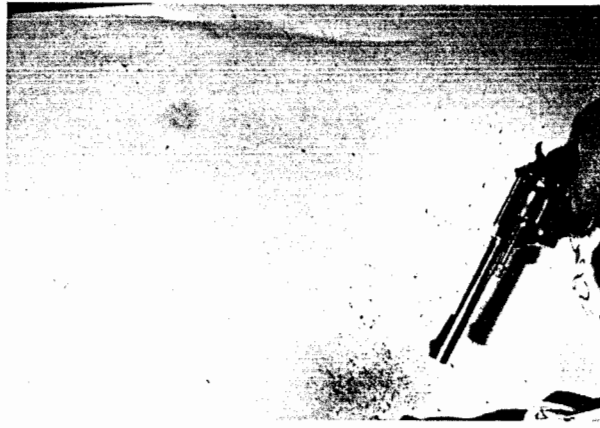


FIG. 2—Placing the weapon back in the original position after the shot. The relationship of droplet size versus distance traveled can easily be seen.

When these tests were concluded, another experiment was performed by saturating a human hair wig with blood just before a shot. Again the tests were performed at contact, near contact, and muzzle-to-target distances up to 1 ft (0.3 m).

Human blood preserved in acid citrate dextrose was used in all tests.

In these experiments, the shooter wore long sleeve shirts of cotton and wool blend under a white lab coat. This combination provided excellent contrast for photographic purposes (Figs. 3 and 4).

For transfer patterns, various bloody objects, such as clothing, wood pencils, and a knife were lightly touched to clean linen. The light touch to cloth was repeated several times while the blood was drying in an attempt to possibly duplicate a pattern that might be confused with a high velocity bloodspatter pattern on cloth (Fig. 5).

Finally, for comparison to the .22 rimfire, a Smith and Wesson Model 19 .38 special was discharged in contact with the bloody sponge to study the blood droplet diameter in comparison with the distance traveled.

Observations

For .22 caliber weapons, backspatter was observed when the muzzle-to-target distances are contact or near contact upon a dry surface.

The addition of clothing will restrict the return of blood toward the shooter. The thicker the outer layer covering, the closer the muzzle must be to create the spatter. It was possible to inhibit completely backspatter in circumstances where the weapon contacted thick clothing in front of the blood filled target.

If the outer clothing was saturated with blood before shooting, contact or near contact geometry was not required. However, the muzzle-to-target distance is still limited to 6 in. (15 cm) or less. This shooting into exposed wet blood normally did not cast the blood any further than contact shots into blood concealed in a plastic bag.

The distance blood droplets will be cast when the weapon is held horizontal and perpendicular to the nonbloody target appears to be dependent on the particle size. The backspatter aerosol mist appearance (droplets less than 1 mm) from a single-contact or near-contact shot in this type surface was limited to approximately 2 ft (0.6 m) (Fig. 6).

In another situation, when shooting into a blood soaked hair wig at 60° from horizontal, similar to Fig. 1, droplets 0.1 mm in size were cast forward 22 to 26 in. (56 to 66 cm). Drop-

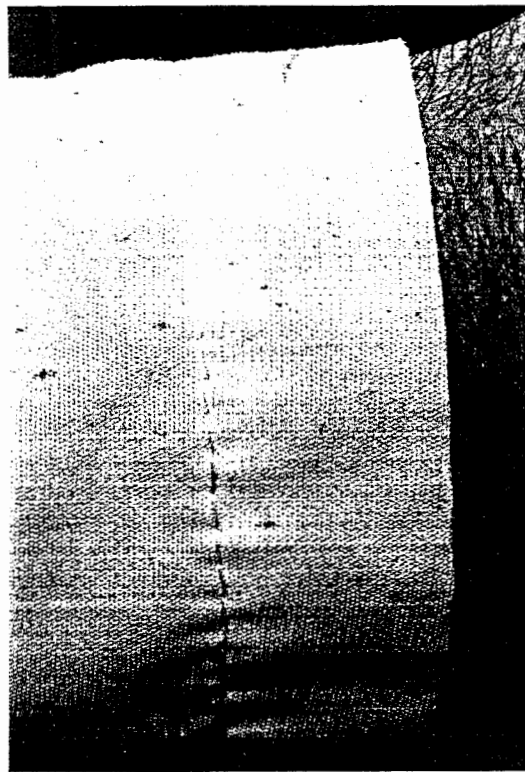


FIG. 3—Photo depicts the shooter's cuff after a contact shot into a blood smeared sponge.

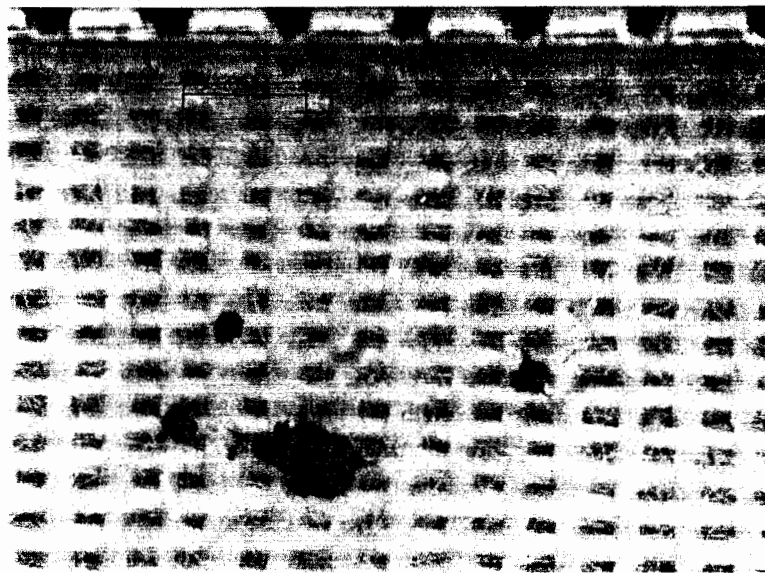


FIG. 4—Bloodspatter deposited on the shooter's cuff from a contact shot into a blood soaked sponge. Blood is visible on the fiber tops and in the valleys ($\times 50$).

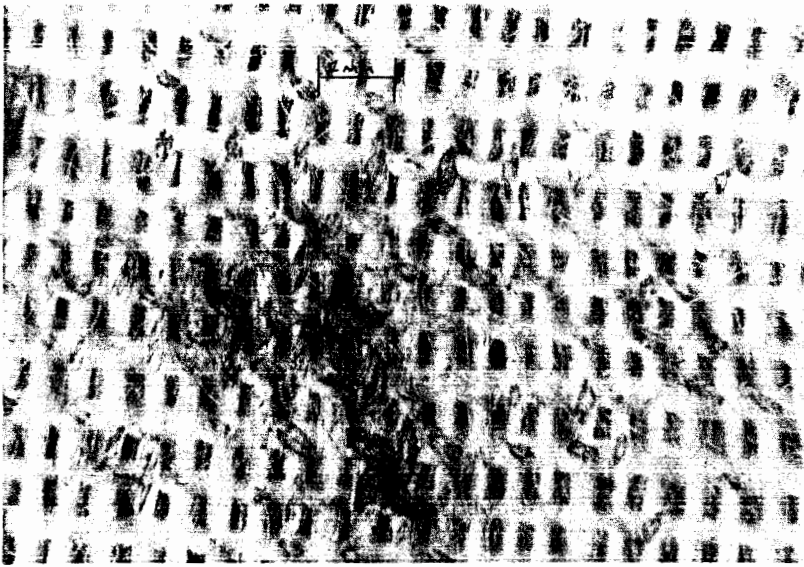


FIG. 5—Transfer pattern of blood on white linen. The small bloodstained areas are only on the fiber tops.

lets 0.5 mm in diameter were cast forward to 48 in. (122 cm). To get a 0.5-mm droplet to travel this distance, the vector forces of the hot gases exiting the muzzle must drive most of the blood droplets in a forward direction. The resultant display is a fan shaped deposition on the horizontal surface.

These small droplets dry rapidly after deposition on an adjacent object or hand and become rigid. However, because of the elastic nature of the skin, they may fall from most areas of the shooting hand within minutes. Survival of these tiny droplets was found to be better on the fingernails than surrounding skin. On inanimate objects, where absorption is limited, spattered blood may exhibit a raised edge and concave center consistent with looking down on a volcano (Fig. 7). This was not observed on transferred blood patterns.

Several tests were performed where the angle of the muzzle to target was varied. When the muzzle is pointed upward, the observed spatter was predominately on the top of the shirt sleeve. Conversely, a downward shot produced more spatter on the lower sleeve. These small droplets strike the cloth randomly with regard to weave or design. It may be visible on the inside, outside, or leading edge of a long sleeved shirt cuff.

Transferred patterns were usually much larger in diameter than bloodspatter and appeared in closely related groups. Blood on a solid object lightly touched to cloth often will produce several stains in closely related groups. They also stain only the top surfaces of the weave.

Discussion

High velocity backspatter from a .22 caliber pistol or revolver can produce a pattern on a shirt cuff of a shooter in a contact or near contact shot. When present, this spatter can be differentiated from transferred blood through careful microscopic examination in the circumstances previously observed. Although it may be found as far up the sleeve as the shoulder, it is usually limited to the cuff or lower sleeve area (specifically the area near the shirt button). If the muzzle is pointed upward the spatter may be viewed higher up the sleeve. A

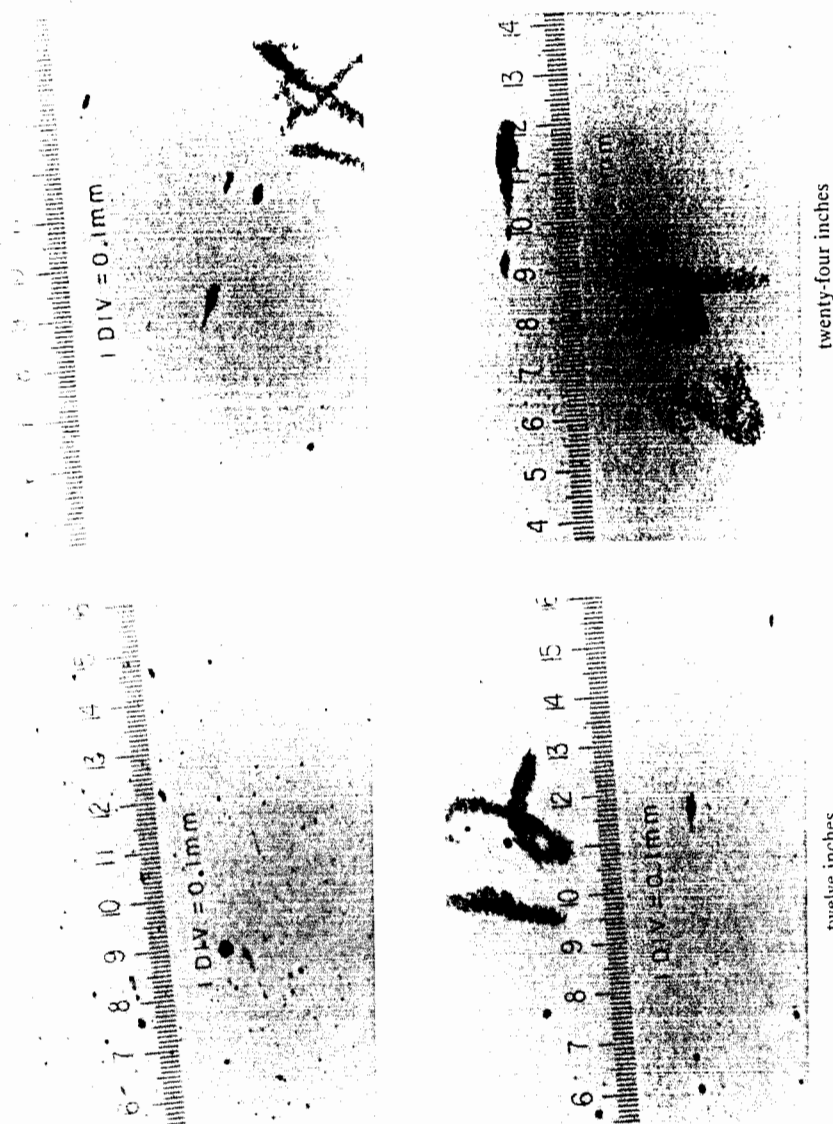


FIG. 6—The above four photographs depict the change in minimum droplet size versus distance traveled. They were created by a contact shot into a blood soaked sponge. The weapon was a .22 rimfire pistol.

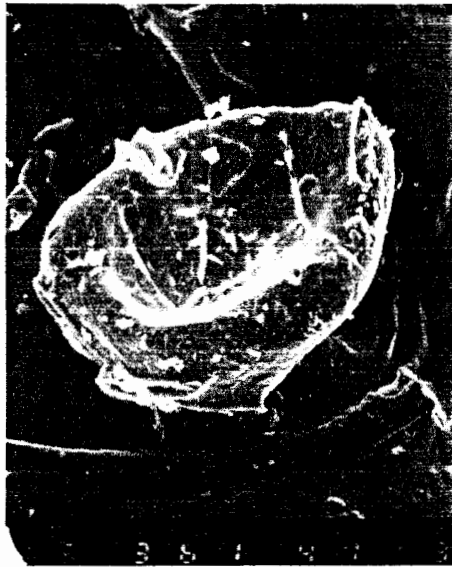


FIG. 7—SEM photomicrograph depicts the concave shape sometimes seen with small blood droplets on nonabsorbent surfaces. Almost instantaneous drying will "freeze" them on impact ($\times 130$).

downward pointed muzzle may shift the pattern toward the underside of the cuff. The observed pattern must not be discounted based on a limited number of droplets. The droplets may still be insufficient for typing purposes, and the relationship to the victim can only be inferred by the specific circumstances in which this pattern may have occurred.

Under identical circumstances, a .38 caliber handgun will produce a denser backspatter pattern than a .22 caliber handgun; however, several comparative tests and microscopic examination have revealed the droplets less than 0.1 mm in size from the .38 do not travel any greater distance than was reported here for a .22.

The kinetic energy transferred to the blood containing surface comes from two main sources: the kinetic energy associated with the bullet, and a portion of the kinetic energy associated with the expanding gas. The former, expressed in foot-poundal is:

$$\text{K.E.} = WV^2/2g$$

where

- K.E. = bullet energy in foot-poundal,
- W = bullet weight in pounds,
- V^2 = impact velocity in ft/s, and
- g = gravitational constant 32 ft/s/s.

The latter depends on the distances involved in muzzle to target.

The 158-g bullet from a .38 spl cartridge develops approximately 60-ft-lb (2.5-J) greater energy than a 40-g bullet from a .22 long rifle cartridge. Our observations indicate that an increase in kinetic energy, with the aid of associated gases, will increase the number of droplets escaping from a bloody surface. The exact hydrodynamics of this process are not clearly defined. Perhaps future studies may enable us to understand the way in which the available energy is shared among different size particles. Since the kinetic energies of both the .38 and .22 caliber cartridges are relatively close, it is difficult to see the difference, if any, reflected

in the droplet trajectory distances. Similar size blood droplets travel roughly the same distance. This is consistent with the notion that the trajectories of these small droplets are controlled primarily by air friction.

If indeed air friction is the dominant mechanism, then it is not surprising that small droplets are not observed at great distances. In the limit of small velocities (Stokes law limit), the distance traveled should be linearly proportional to the droplet size. This prediction assumes that all different size droplets started off with the same initial velocity and further that they are in free flight.

When you take the above facts into consideration and compound the problem with muzzle-to-target distances and target-to-nearby-object distances, it would in most cases be purely speculative to assign a specific caliber weapon to a bloodspatter pattern.

Conclusion

It is recommended that the examiner attempt to duplicate any questioned pattern with a garment of similar fabric and the same weapon and ammunition, if available. Past experience has shown the necessity to document carefully bloodspatter patterns by photography. Small droplets may flake and drop from their support with time.

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