J Forensic Sci, Oct. 1979, Vol. 24, No. 4

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Particle Analysis for the Detection of Gunshot Residue. III: The Case Record

The final step in the development of the particle analysis method for gunshot residue detection was a program of case assistance for law enforcement agencies, carried out during the first nine months of 1977.

This program was to be in the nature of a field test designed to disclose any additional problems and requirements not encountered in the preceding research [*1,2*]. In addition, it was meant to acquaint more criminalists with this new method and speed its transfer from the research laboratory to the criminalistics laboratory.

Such laboratories, as well as police and sheriffs' departments, the latter two usually through their local criminalistics laboratory, were given information and sampling kits and invited to submit cases. Submitting criminalists and investigators were invited to witness the examinations in our laboratory and often did so. In each case, a written report was furnished; the report described the findings, listed the particles found, and included some brief interpretative remarks when deemed necessary. In some cases, when requested or subpoenaed, court testimony was rendered.

The Cases and Definition of Success Rate

Table 1 provides information on the first 86 cases that fall into one or another of the three categories chosen for this evaluation: homicides/assaults, suicide/homicide decisions, and suicide verification.

Homicides/Assaults

The first category, labeled "homicides/assaults," consists of cases in which someone fired a gun, but not at himself. Samples from the hands of one or several suspects, and in most cases a test-firing sample, were analyzed for the presence of gunshot residue. To calculate a "success" rate, the assumption was made that at least one of the suspects was in fact the correct one, so that a successful analysis would consist of at least one positive sample. Since this assumption could occasionally be wrong, equating positive results with successful analyses and negative analyses with failures insures that the actual success rate is at least as high as the number given, but it could be higher. Three cases are labeled inconclusive in the table. In each of these cases, only a few irregular lead particles

This work was supported under a contract from the Law Enforcement Assistance Administration. Received for publication 4 Jan. 1979; revised manuscript received 26 Feb. 1979; accepted for publication 2 April 1979.

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TABLE 1—*Summary of the first 86 cases of analyses of samples from hands.*

Category	Handgun Cases, *n*	Rifle and Shotgun Cases, *n*	Rate of Positives	
			Handguns, %	Overall, %
Homicides/assaults				
Residue found on at least one suspect	28	5	88	79
No residue found	2	4	...	...
Inconclusive	2	1	...	...
Suicide/homicide decision				
Residue on victim or suspect or both	8	...	89	89
No residue found	1	...	...	...
Suicide verification				
Residue on victim's hands	29	2	94	89
No residue found	2	2	...	...
Overall				
Residue found	65	7	90	84
Residue not found or inconclusive	7	7	...	...

were found. These could have been gunshot residue, but were not characteristic enough to result in a positive finding. For purposes of statistics, these cases were combined with the "failures," cases in which nothing was found that could be interpreted as gunshot residue or consistent with gunshot residue.

The average time lapse between firing and sampling was 3¼ h, with a range from 1 to 13 h for live subjects. There was no difference in the average time lapse between cases with positive and negative results. Considering handguns only, the four negative results all involved cartridges that tend to give sparse residues, but because such cartridges were also adequately represented among the positive results, that aspect cannot be considered the determining factor. Two of these four cases took place indoors and two outdoors.

Results were considered positive in this tabulation when particles were found that were either uniquely characteristic of gunshot residue or consistent with it. Approximately two thirds of the positive results so defined involved unique particles.

On the foregoing basis, the positive rate was 88% where handguns were involved and 50% for the much smaller number of cases involving shotguns and rifles, for an overall rate of 79%. The research preceding the case work did not include a study of these long guns, so that the conditions for detecting residue deposited by them were not optimized. The homicide/assault category includes the most successful as well as the least promising case that was handled. One of the positive results for handguns involved a single shot from a .22-caliber revolver, with the suspect being sampled 13 h after the firing. He was asleep for 6 h and awake for 7 of the 13 h. This is the most successful case. One of the negative long gun cases involved a .22-caliber rifle. This was the least promising case because the suspect was sampled 15 h after the shooting occurred. Generally, accepting cases for live suspects after a delay of more than 12 h is not recommended.

Suicide/Homicide Decisions

The second category, "suicide/homicide decisions," involved examination of samples from both the victim and one or more suspects. The assumption was again made that there should be at least one positive sample, other than the test-firing sample, in the lot. Such a positive sample was found in eight of the nine cases, all of which involved handguns only, for a success rate of 89%.

Suicide Verification

The final category, "suicide verification," consists of cases for which samples from only the victim were submitted. For statistical purposes, it is assumed that all of these are bona fide suicides and require a positive result. This was obtained in 94% of the handgun cases and in 50% of the four cases involving long guns, for an overall rate of 89%. However, based on experience, a negative result in an apparent suicide by handgun seems highly suspicious and should be further investigated if it can be ascertained that the victim's body has not been disturbed up to the time of sampling. The interpretation of evidence in apparent suicide cases is further discussed later in this report.

The tendency was for victims to be sampled much later than live subjects. The average time lapse was 15 h, with a range from 1½ to 120 h. The suicide victim who was sampled 120 h later yielded ample residue, more than many others. Presumably, this body was sampled while still completely undisturbed.

Summary

By averaging all three categories, positive results were obtained in 90% of the handgun cases and 50% of the long gun cases, or 84% overall. Bearing in mind the assumptions made, these are the minimum rates of success for particle analysis applied to 86 cases.

It is instructive to examine the history of the overall handgun success rate, which was calculated at several stages of the program. When 51 cases had been completed, it was 95%. It had dropped to 90% upon completion of the 86 cases included in Table 1. In the interval between this tabulation and the end of the Law Enforcement Assistance Administration (LEAA) program, 17 additional handgun cases dropped the rate to 88%.

It is known that cases submitted at the beginning of the program often were cases that the submitting agencies felt certain of and used as a test of the method. As time when on, more and more of the cases were genuine unknowns, so that some of the negatives may have been true rather than false negatives. Towards the end of the program, there emerged a tendency to submit only those cases assumed to be difficult ones.

Impact

The criminalists and detectives at whose requests the analyses were performed generally agree on the usefulness of the results in the investigative and pretrial phases of cases. In a number of instances the existence of the evidence caused the defendant to change his plea.

Aerospace Corporation personnel and criminalists who witnessed some examinations in our laboratories have testified in court in a number of cases, some of which resulted in convictions of the defendant.

One case has gone to appeal. The appeals court upheld the conviction and specifically affirmed the scientific validity of the method [*3*].

Special Problems

Interpretation of the Evidence in Suicides

A person committing suicide obviously cannot hold the gun in the normal firing attitude that was used to arrive at the characteristics described in this series of papers. Experience from cases suggests, however, that generally the number of particles deposited on the victim's hands at the time of firing is at least equal to that resulting from normal firing when a handgun is used. There is not enough experience with long guns to make a

similar statement for these, but it would seem that they afford greater opportunities for variations because of the problem of manipulating the gun.

The loss of residue from the hands of live subjects as a function of time probably consists in part of the particles simply falling off, but loss may be accelerated by activities that tend to wipe the hands. Some suicide victims who died instantly and were sampled before the body was disturbed had ample residue on their hands as many as five days later, which was the longest delay encountered in any of the cases. Other cases tend to indicate that handling of the body and transportation can result in loss of residue to varying degrees.

Not enough data are available to decide whether bagging of the hands is beneficial or detrimental to the preservation of the residue. However, this practice is viewed with some reservation because the residue can be wiped off the hand during the bagging process or by subsequent motion of the hand against the inside of the bag.

If the victim does not die immediately and is rushed to a hospital, the attempts to save his life obviously take precedence over preservation of the evidence, and the residue may be lost.

If it can be ascertained that the victim's hands were sampled before any serious disturbance of the body has taken place, a failure to find gunshot residue is suspicious enough to cause a further investigation into the possibility of a disguised homicide. However, if gunshot residue is found, this does not prove that the victim shot himself. The residue could have come from the muzzle blast of a gun held by another person. If the victim is aware of being attacked, especially at close range, he or she is quite likely to throw up his or her hands in a defensive gesture and thus receive the full muzzle blast on the hands.

A difficult situation arises if both the victim and a potential suspect or witness (who may also become a suspect) are found to have gunshot residue on their hands. If the suspect's residue is ample and the victim's sparse, homicide appears likely. In the reverse situation, the explanation may be accepted that the victim committed suicide and that the survivor picked up some residue by handling the gun or by handling the victim to see if he was still alive or to assist. However, if a few hours have elapsed before the survivor is sampled, the small amounts of residue found on him may be consistent with his having fired the gun a few hours earlier. In the light of all the circumstances, it will then have to be decided whether or not the survivor is a suspect in a possible homicide.

Samples Contaminated with Blood

Samples were frequently received in suicide cases in which dried blood was present on the surfaces of the disks. In our experience, this has interfered with the detection of gunshot residue by particle analysis in only one case. In this case, the most probable, although somewhat speculative, interpretation of the facts suggests that the flow of blood over the hands was so copious as to wash the hands clean of gunshot residue.

Perspiration

No difficulties were encountered with samples taken from heavily perspiring hands. It may be that residue clings better to moist hands and that this compensates for a possible lowering of the effectiveness of the adhesive used to collect the residue. Samples from heavily perspiring hands are much richer in salts and skin debris than samples from dry hands.

Long Guns

During the course of this program, residue from the firing of some rifles and shotguns was collected for characterization, but ultimately it was not possible to include this task

within the scope of the program. Thus, the only information acquired about residue left on hands by long guns comes from the 15 cases submitted by law enforcement agencies that involved the use of such weapons.

It is hazardous to draw conclusions from such a small number of cases. Shotgun cases gave four positive results out of five and rifles only three out of eight. Of the three positive rifle examinations, two involved bolt-action guns, and one was a semiautomatic. The five negatives were either semiautomatic or lever-action rifles. It is still assumed that all results should have been positive. A .22 rifle used to fire birdshot was not included in this summary because no decision was reached as to whether it should be treated as a rifle or as a shotgun case. It gave a negative result.

It appears that rifles deposit much less residue on the hand than handguns. This could simply be the result of the much higher muzzle velocities of rifle bullets compared to handgun bullets. The decline in the number of particles with increasing velocity and barrel length was described in the first article in this series [*1*]. It may also be that most rifles have tighter breech mechanisms and allow less residue to escape. Alternatively, it is possible that the spatial distribution pattern is different. No attempt was made to look for residue on the face of the shooter. This may be a worthwhile experiment.

Shelf-Life of Adhesive Used for Sampling

The adhesive (Scotch Transfer Tape 465) is sold currently only in lots of twelve rolls (at slightly under $0.50 per roll). One lot is enough tape for many years for the average agency. However, because of gradual loss of stickiness, it is recommended that tape be discarded after 18 months if stored in a refrigerator or after 12 months if not refrigerated.

Time Required for Analysis

The time spent on analyzing a sample varies with experience, the fraction of the area examined, the amount of gunshot residue found, and the amount of extraneous material in the sample. Photographing particles or X-ray spectra takes additional time. The average for all samples in the cases that were handled was 1¼ h per sample.

The number of samples per case also varies. The minimum is two, one from each hand of one suspect. There may be more than one suspect or more than two samples per suspect, and in most cases a sample from test-firing the suspect's ammunition is also submitted and analyzed. Sometimes not all samples that were submitted needed to be analyzed, but the average number actually analyzed in 69 cases was four samples per case, with a standard deviation of 2.

Conclusions

Particle analysis has been fashioned into the most definitive method of identifying and the most successful method of detecting gunshot residue to date. It identifies gunshot residue with greater certainty than any previous method because discrimination from a majority of occupationally caused deposits of lead, barium, or antimony is possible. It is effective for a much longer time after a firing than previous methods because particle analysis does not have a threshold problem. Analysis of about 120 actual cases has established the readiness of this new method for use by forensic science laboratories.

Gunshot residue can be found on a person's hand not only if the subject fired a gun, but also if he handled a recently fired gun or was a close bystander at a shooting. This investigation has contributed to clarification of the circumstances under which transfer of residue can occur and the amounts that can be expected as a result of such a transfer.

Finding particles other than gunshot residue particles can furnish significant clues to

the subject's recent activities or environment, both in firearms-related and other types of cases. Therefore, it would be useful to expand the range of environmental and occupational particles to be investigated.

The most important step now required is to increase the availability of the equipment to criminalistics laboratories and the skills to carry out particle analysis. Beyond this, large service laboratories may require automation of the procedures.

Summary

The first two papers in this series described, respectively, the nature of gunshot residue particles as seen in the scanning electron microscope with an X-ray analyzer and the nature and distinguishing features of possibly similar industrial and occupational residue particles. The present paper describes the first extensive application of the method to case work. Eighty-six cases in which samples from hands were submitted for analysis by law-enforcement agencies are evaluated statistically. Gunshot residue was found in 90% of the cases that involved the use of handguns and in 84% of all cases. Interpretation of the evidence is discussed. Because an experienced operator can average two thorough case analyses per 8-h working day, the method is labor-intensive, but relief through automation appears possible.

A Final Note

The previous two papers in this series appeared in the April 1979 issue of the *Journal of Forensic Sciences*. Together, the three papers summarize the principal findings of the study and the salient features of the new method. Additional information, data, and experimental details can be found in Aerospace Corporation Report ATR-77(7915)-3, available on request. Persons wishing to practice particle analysis for gunshot residue determination are encouraged to write for a copy of the report.

References

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