

George E. Reed,¹ M.F.S.; Phillip J. McGuire,² M.F.S., M.S.A.;
and Alan Boehm,³ M.F.S.

Analysis of Gunshot Residue Test Results in 112 Suicides

REFERENCE: Reed, G. E., McGuire, P. J., and Boehm, A., "Analysis of Gunshot Residue Test Results in 112 Suicides," *Journal of Forensic Sciences*, JFSCA, Vol. 35, No. 1, Jan. 1990, pp. 62-68.

ABSTRACT: The results of gunshot residue (GSR) tests in 112 suicide cases investigated by the U.S. Army Criminal Investigation Command over a ten-year period are described. Only suicide cases in which there was certainty that the victim fired a weapon were examined in an effort to reduce ambiguous results. Previous case work research by Rudzitis indicated that positive GSR test results were encountered in suicides 62% of the time using various combinations of neutron activation analysis (NAA) and atomic absorption spectrophotometry (AAS). Threshold values of 0.2- μg antimony and 0.3- μg barium (0.2- μg antimony and 0.5- μg barium after 1985) used by the U.S. Army Criminal Investigation Laboratory resulted in positive GSR results in suicide cases 38% of the time. The effects of time, location of body, handling of the body, weapon type, caliber, and condition of the hands on GSR results are examined. Case studies involving suicides by unit armorers are discussed.

KEYWORDS: criminalistics, gunshot residues, suicide, atomic absorption spectrophotometry, case studies

Gunshot residue (GSR) tests are conducted on the hands of suspects and victims in the hopes of determining who fired or handled a firearm. Interpreting test results is a problem because the tests cannot generally be considered conclusive due to the number of factors affecting residue deposition, retention, and collection. Case studies, such as those conducted by Rudzitis [1], are particularly helpful in determining environmental and procedural variables that may affect GSR results.

In this study, 112 suicide reports were examined in an effort to determine which factors had the greatest effect on GSR test results. Only suicides were used to eliminate variables associated with actions taken by the shooter to remove residue encountered in other types of cases. Because collection and test procedures were the same in all of the cases, variables such as weapon type, location of the body, condition of the hands, time delay in swabbing, and number of shots fired were examined. In addition to variables that

From the Department of Forensic Sciences, The George Washington University, Washington, DC. The opinions contained herein are those of the authors and are not to be construed as official or as reflecting those of The George Washington University, the Department of Defense, or any branch thereof. Received for publication 21 Oct. 1988; revised manuscript received 3 Jan. 1989; accepted for publication 3 Feb. 1989.

¹Captain, M.P., Executive Officer, Frankfurt District, 2d Region, U.S. Army Criminal Investigation Command, Frankfurt, Federal Republic of Germany.

²Special Agent, Forensic Sciences Coordinator, 7th Region, U.S. Army Criminal Investigation Command, Seoul, Republic of Korea.

³Special Agent, Forensic Sciences Coordinator, 2d Region, U.S. Army Criminal Investigation Command, Heidelberg, Federal Republic of Germany.

affect test accuracy, it is also useful to know how often positive results are obtained under particular conditions to place GSR tests into proper perspective for investigation and courtroom testimony.

Materials and Methods

Between 1978 and 1988 the U.S. Army Criminal Investigation Command (USACIDC) conducted 112 investigations of suicides in which the victim used a firearm and a GSR test was conducted. The investigative files and the attached laboratory reports were examined at the U.S. Army Crime Records Center (USACRC), Baltimore, Maryland. The data were then transferred to an automated database for analysis. In all 112 cases it was determined that the victim fired the fatal shot and swabbings of the victim's hands were submitted to the U.S. Army Criminal Investigation Laboratory for analysis. Since USACIDC has worldwide investigative responsibility for felony crimes of an Army interest, the cases were not limited to those occurring within the continental United States.

Sampling was conducted in the field by trained criminal investigators. Swabbings were made using cotton swabs of the palms and backs of the shooting and nonshooting hands. The swabs and pertinent case information were submitted to the U.S. Army Criminal Investigation Laboratory (USACIL) for analysis using atomic absorption spectrophotometry (AAS). Until 1985, USACIL used 0.2- μg antimony and 0.3- μg barium as threshold values for a "positive" indication of gunshot residue. After 1985 the barium threshold was raised to 0.5. Both elements must have been present above threshold levels to result in a GSR-consistent finding.

Results

Gunshot residue testing is routinely conducted in suspected suicides where firearms are used. In Table 1 the yearly case rate and the percentage of tests resulting in a positive finding are illustrated. The number of GSR tests fluctuated with case load during the study period. The marked drop in 1983 resulted when the laboratory moved and conducted fewer tests. At the time of this writing, only one suicide case with GSR results was on file at USACRC for 1988.

When examining weapon types in relation to GSR-consistent findings (Table 2), it was discovered that positive results were obtained more than 50% of the time with M1911A1 .45 caliber pistols, M16A1 .223 caliber rifles, .357 revolvers, and 20-gauge shotguns. Although .38 caliber pistols were positive at a rate of 67%, there were only three incidents

TABLE 1—*Gunshot suicides per year with GSR test conducted.*^a

Year	Cases	Percent of Positive Findings
1978	5	40
1979	8	38
1980	7	14
1981	10	30
1982	11	55
1983	8	13
1984	18	50
1985	17	47
1986	17	41
1987	10	20

^aOnly one 1988 case was on file as of 1 July 1988.

TABLE 2—Weapon types.

Weapon Type	<i>n</i>	<i>n</i> +	% +
Pistols	34	16	47
.22	3	0	0
.25	6	1	17
.38	3	2	67
.45	17	11	65
9MM	5	1	20
Revolvers	43	12	28
.22	8	0	0
.32	7	2	29
.38	14	5	36
.357	11	6	55
.44	2	0	0
Unk	1	0	0
Rifles	21	9	43
.22	2	0	0
.223 M16A1	13	7	54
.30	4	2	50
.44	1	0	0
7MM	1	0	0
Shotguns	14	6	43
.410 gauge	5	1	20
12 gauge	4	2	50
16 gauge	2	1	50
20 gauge	3	2	67
Total	112	43	38

in which this type of weapon was used. In all thirteen cases in which .22 caliber firearms were used by the victim the GSR test was negative as a result of the absence of antimony and or barium in the primer of the .22 caliber rimfire ammunition.

Of particular interest is the result from M1911A1 .45 caliber pistols. Pistols would not normally be expected to produce such high GSR-consistent findings [2-4]. A "tight" gun such as a pistol would not normally be expected to produce enough residue on the back of the hands for a positive GSR. Rudzitis [1] noted that in 23 cases involving .45 caliber weapons only 3% positive GSR results were obtained. A higher incidence of GSR-consistent findings would be expected if the firer had extensively handled the weapon (for example, multiple loading, unloading, and cleaning) resulting in residue on the palms of the hands. This was not the case in the present study as all of those who committed suicide with a .45 caliber pistol fired only one fatal shot. One explanation for the high number of positives results with the .45 caliber pistols may be that the military weapons used were not tight as a result of years of hard use. Although in good operating condition, many military .45 caliber pistols have been used for extended periods and have been rebuilt or extensively repaired. Other researchers have also noted higher concentrations from M1911A1 pistols [5]. In 92% of the 112 examined cases, only 1 shot was fired. There was no evidence of multiple loading and unloading. When only one shot was fired, positive results were obtained 35% of the time. When more than one shot was fired, positive results were obtained 50% of the time.

The significantly high number of M1911A1 .45 caliber pistols used in suicides by soldiers serves to explain why an analysis of GSR-consistent tests by type of weapon used shows that pistols result in a 50% GSR-consistent finding.

In determining the time between the fatal shot and the time of swabbing of the victim's hands a conservative approach was taken. If a window of time was given for an un-witnessed suicide, researchers recorded the earliest time as the time of the shooting. Thus,

if the suicide was believed to have occurred between 2000 to 2200, and the swab was taken at 2300, the time between shot and swab would have been recorded as 3 h. Almost half of the swabs were taken within 4 h as shown in Table 3. Because the victims could not engage in actions which would be expected to remove residue, time would not be expected to be an important factor. The high number of positive results when the swabbing was done between 9 and 12 h after the shooting is a reflection of the number of cases tested in this time period where .45 caliber pistols were used. Positive results dropped off significantly after 12 h.

More important than the amount of time that has passed is the condition of the hands at the time of swabbing. In Table 4 a strong correlation between hand condition and GSR-consistent findings is illustrated. Dry and clean hands resulted in positive findings 45% of the time. Hands recorded as being bloody were generally not covered with blood, but had blood splatters which were not enough to wash away the residue resulting in a positive finding 44% of the time. Positive findings were low when there was decomposition and after the hands were washed. In one case, a positive finding was obtained after the victim was discovered an estimated 40 days after being reported missing. The body was found in a wooded area in Alaska and was entirely frozen. The weapon used in the suicide was a .25 caliber Raven Arms pistol. Only one shot was fired. Investigators bagged the hands of the victim at the scene and conducted swabbing at the morgue.

There is little difference between results when swabbing is conducted at the scene or morgue. Swabs taken at the scene resulted in a GSR-consistent finding 39% of the time, while swabbings taken at the morgue were positive at a rate of 38%. In Table 5, on the

TABLE 3—*Time between shot and swab.*

Time Span, h	n	% +
0-4	51	31
5-8	22	27
9-12	11	64
13-24	8	13
25-48	4	0
49+	9	11
Total	105 ^a	

^aThe number of cases in the time span column do not add up to the total number of cases because in some reports the time span was not listed.

TABLE 4—*Condition of hands at the time of swab.*

Hand Condition	n	% +
Dry and clean	51	45
Bloody	36	44
Wet	4	25
Decomposed	4	25
Washed	3	0
Frozen	1	100
Dirty	1	0
Unknown	12	8
Total	112	

TABLE 5—*Body movement.*

Movement of Body Before Swabbing	<i>n</i>	% +
Body not moved	49	39
Body moved with hands bagged	24	58
Body moved hands not bagged	35	29
Unknown	4	
Total	112	

other hand, it is illustrated that higher GSR-consistent results are obtained when the swabbing is conducted before the body is moved or when the hands are protected by bagging. Positive results are significantly less when the hands are not bagged.

Suicides by Unit Armorers

Unit armorers routinely handle large numbers of fired and unfired weapons as part of their daily duties which include issuing, receiving, accounting for, inspecting, and maintaining military weapons. Unit arms rooms are areas of controlled access, with minimal ventilation and air flow. Military weapons also result in positive GSR test results at a rate higher than most civilian firearms. Cases involving suicides by armorers in arms rooms using military weapons should have all of the prerequisites for large deposits of GSR on the victim and correspondingly high GSR-consistent findings.

Case reports involving the gunshot suicides of six unit armorers were included in this study (Table 6). Of these six cases, four of the suicides were committed in unit arms rooms. Five of the victims used military weapons with three being M1911A1 .45 caliber pistols, two used M16A1 .223 caliber rifles; one victim used a privately owned weapon, a Ruger .38 caliber revolver. All victims fired only one shot. GSR-consistent results were obtained in only two of the cases of which one occurred in the arms room. In both cases in which the GSR test was positive the hands were dry and clean, and the hands were either swabbed before the body was disturbed or the hands were protected by bagging before transport. Once again, the important characteristics for GSR-consistent results appear to be that the hands are dry and clean and that the hands are swabbed before the body is moved or the hands are properly protected by the use of paper bags.

Conclusion

The study of 112 suicide cases in which gunshot residue tests were conducted revealed a GSR-consistent opinion 38% of the time when AAS is used. Weapons resulting in the highest numbers of positive tests were .45 caliber pistols, .223 caliber rifles, .357 caliber revolvers, and shotguns. The most important factor in obtaining good test results is not time delay, location of the body, or weapon characteristics. The single most important factor in obtaining accurate results is condition of the hands before swabbing. Hands that were dry, clean, and tested at the scene, or at least protected by paper bags, resulted in the most GSR-consistent results. Cases in which the hands were not safeguarded before transportation to the hospital or morgue resulted in low positive test results.

Acknowledgments

The authors thank Mr. Robert Brisentine, Director, U.S. Army Crime Records Center, and the personnel of the Records Maintenance Branch, USACRC, for their assistance

TABLE 6—Cases involving unit armorers.

No.	Results	Occurred in Arms Room	Make and Model Weapon	Hand Condition	Hours Time Delay	Hand Disturbance
1	negative	no	M1911A1 .45	decomposed	360	not moved
2	negative	yes	M16A1 .223	bloody	5	not bagged
3	negative	yes	M16A1 .223	unknown	4	not bagged
4	negative	yes	M1911A1 .45	dry/clean	36	unknown
5	positive	yes	M1911A1 .45	dry/clean	4	bagged
6	positive	no	Ruger .38	dry/clean	4	not moved

and cooperation. The comments and contributions of Dr. Walter F. Rowe, Department of Forensic Sciences, The George Washington University, and Mr. Larry Flinn of the U.S. Army Criminal Investigation Laboratory, Fort Gillem, Georgia, are also gratefully acknowledged.

References

- [1] Rudzitis, E., "Analysis of the Results of Gunshot Residue Detection in Case Work," *Journal of Forensic Sciences*, Vol. 25, No. 4, Oct. 1980, pp. 839-846.
- [2] Krishnan, S., "Detection of Gunshot Residue on the Hands by Trace Element Analysis," *Journal of Forensic Sciences*, Vol. 22, No. 2, April 1977, pp. 304-324.
- [3] Cowan, M. and Purdon, P., "A Study of the Paraffin Test," *Journal of Forensic Sciences*, Vol. 12, No. 1, Jan. 1967, pp. 14-36.
- [4] Stone, I. and Petty, C., "Examination of Gunshot Residues," *Journal of Forensic Sciences*, Vol. 19, No. 4, Oct. 1974, pp. 784-787.
- [5] Kilty, J. W., "Activity After Shooting and Its Effect on the Retention of Primer Residue," *Journal of Forensic Sciences*, Vol. 20, No. 2, April 1975, pp. 219-230.

Address requests for reprints or additional information to
Captain George E. Reed
U.S. Army
USACIL-Europe
APO, NY 09757