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Gunshot Residue in Chicago Police Vehicles and Facilities: An Empirical Study*

ABSTRACT: Suspects in shooting investigations in Chicago are routinely transported in department vehicles and detained in department facilities prior to gunshot residue (GSR) evidence collection. The GSR test results are used to associate the suspect with primary exposure to GSR. The potential for these vehicles and facilities being sources of secondary GSR contamination needed to be determined. A total of 201 samples were collected from randomly selected vehicles and detention facilities. The sampling collected trace materials from surfaces that suspects' hands may contact during the arrest process. These samples were examined for the presence of GSR particles using scanning electron microscopy. Upon completion of the automated analysis, those particles that met an initial GSR screening criterion were relocated and reanalyzed. The locations where GSR particles were recovered allowed us to make recommendations to the Chicago Police Department with regard to transporting and detaining these suspects. The low number of GSR particles recovered suggests that the potential for secondary contamination, although present, is relatively low.

KEYWORDS: forensic science, trace evidence, scanning electron microscopy, gunshot residue, atomic absorption spectroscopy, energy dispersive X-ray spectroscopy, backscatter electron detector system, secondary transfer, Chicago

Since the mid 1980s, the Chicago Police Department had used atomic absorption spectroscopy (AAS) gunshot residue (GSR) kits to collect GSR evidence from suspects' hands. Scanning electron microscopy (SEM) with energy dispersive spectroscopy (EDS) has greatly improved the ability to identify GSR (1,2). Prior to converting from the bulk collection of GSR evidence to particle analysis, an environmental study of Chicago Police vehicles and detention facilities warranted investigation.

The Chicago Police Department divides the city into 25 "Districts" and five larger "Areas." Marked squad cars, squad rolls ("paddy wagons") and unmarked Tactical Team cars are assigned to Districts, and unmarked Detectives' cars are assigned to Areas. These vehicles are typically used to transport suspects. While in the District and Area facilities, suspects are typically detained in offices or Interview Rooms that contain tables, chairs, or metallic benches with restraining bars or rings to which they are handcuffed. Samples were collected from surfaces that the suspects' hands were likely to encounter, even if they were handcuffed.

Methods

Samples were collected from 193 vehicles and detention facilities. After the initial samples were analyzed, eight additional samples were taken from multiple locations in two of the facilities.

Samples were collected using SEM GSR kits manufactured by Tri-Tech Incorporated (Southport, NC). The sample stubs are 1/2 inch aluminum circles covered with conductive adhesive tape. In actual casework, these stubs are used to collect evidence from the backs of the suspects' hands. These stubs are applied to the sample surface using a repeated dabbing motion. In our study, random sampling was performed and a large number of particles were collected. As the tape picks up trace materials, the tackiness of the tape decreases. The dabbing continued in the area that the suspects' hands could have contacted until the adhesive tape was no longer tacky. No additional sample preparation was necessary.

The study was done with a R. J. Lee (currently Aspex Instruments, Delmont, PA) Personal SEM with an automated stage. The software purchased with the SEM was used to categorize particles based on a screening criterion. Performance checks and control samples were included in each run for quality assurance.

Results

The identification of GSR particles is based on the elemental composition of the particle and its morphology. These particles contain the three component elements: lead, barium, and antimony, and should have a spherical or noncrystalline appearance.

Of the 201 samples analyzed, 178 lacked the three component primer residue particles. The remaining 23 samples had 56 particles that were confirmed as three component primer residue particles.

Table 1 summarizes the test results. Very few of the three component primer particles were recovered from vehicles. Most of the three component primer particles were recovered from detention facilities.

Table 2 identifies the distribution of where the samples containing the three component primer particles were recovered.

Tables 3 and 4 compare the density of particles recovered that contained lead, barium, or antimony, but were not identified as three component primer particles. This laboratory refers to this measurement as the "load factor." The measurement, in particles per area tested, can be used to compare the results obtained from the sampled surfaces. The lack of three component primer particles and low load factors identify the surfaces that possess the least potential for GSR contamination.

Initial testing of the squad car from the seventh District stood out as a high, unexplained value. It was later learned that that

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TABLE 1—*Confirmed three component primer particles.*

Vehicle/facility sampled	No. of particles confirmed
Marked squad cars	0
Marked squad rolls	0
Detective cars	0
Tactical cars	2
Table-type surfaces	34
Restraining bars	20
Total	56

particular vehicle was routinely used to transport recovered property from abandoned buildings. As the vehicle's usage was unusual and did not fall into the scope of vehicles in the study, those results were treated as an anomaly and not used in comparing vehicles based on the type of seat.

The data in Table 5 identifies the vehicles that are preferred for transporting suspects. While there is some overlap of the ranges of the load factors, the vehicles with the vinyl seats seemed to have the least potential for being a source of secondary contamination.

Discussion

The original research by the Aerospace Group established criteria for the classification of GSR particles: (a) "unique to" or "characteristic of" GSR, and (b) "consistent with" or "not unique to" GSR. The unique or characteristic particles were identified in known GSR standards and were not found in occupational residues. The consistent or not unique particles could be found in known GSR standards, but also in occupational residues. Elements that may be found in trace amounts in the particles were also listed (3). While the focus of the categories has remained the same, the actual particles that were originally placed into those categories and the titles for the categories have changed over the years due to improvements in the analytical technique and research studies.

Currently, it is generally accepted that the detection of particles with the major elemental compositions of lead, barium, and antimony is prerequisite to the identification of GSR. Along with the elemental composition, GSR particles are spherical during formation and may retain their initial shape after being deposited and collected. If not, their appearance would be irregular, but not crystalline. Elemental composition, and morphology are used in GSR identification. The entire population of GSR particles should be used in the interpretation of test results (4).

TABLE 3—*Load factors (particles/mm^2) for Detective's vehicles. 1 vehicle/area sampled.*

Area	1	2	3	4	5
Load	0.71	0.20	0.15	3.74*	2.85*

*Vehicles with cloth seats.

Changes in the titles used for the categories have been recently discussed without unanimous agreement (4). Studies of materials produced by brake pad wear and firework residue showed particles that may be mistaken as GSR by the inexperienced analyst. Concerns about these studies have caused different agencies to refine their terminology.

At the time of this study, this laboratory, in accordance with ASTM guidelines (5), recognized two particle types on the Aerospace Group's list for GSR identification: (i) lead, antimony, and barium; and (ii) antimony, and barium particles. We no longer use antimony and barium particles to identify GSR. This change does not affect test results from this study. Based on the nomenclature used by the Aerospace group, we still refer to these particles as unique GSR particles. We categorize particles containing one or two of the elements as consistent GSR particles.

An in-house, hand blank study was performed by this laboratory to determine the number of GSR particles on the hands of individuals without primary exposure to GSR. Upon analyses, one unique GSR particle and numerous consistent GSR particles were identified. This confirmed the possibility of finding unique GSR particles in samples taken from individuals who had not had primary exposure. This study allowed us to formulate our interpretation guideline. Based on the study, the significant value for the load factor was determined and a minimum of at least three unique GSR particles in a sample was established as a prerequisite to report positive GSR results.

TABLE 2—*Distribution of confirmed three component primer particles.*

Specific district/area	2	5	6	9	12	13	15	16	18	19	20	22	Area 2	Area 4
Interview room			a									a		
Restraining bar	5(b)								1	7(b)			2(c)	(c)
Table surface	1	1				2	1			3	1		1	
Tactical office			a											
Restraining bar					1					3				
Table surface		5		7(d)		2				5	1			
Tactical vehicle								1(e)			1(e)			
Other			1(f)									3(g)		1(h)

(a) These rooms do not actually exist in the particular district. Other rooms used for the same purpose were sampled.
(b) Restraining bars in the 2nd and 19th Districts were re-sampled. One (1) additional unique particle was detected.
(c) The restraining ring had a set of handcuffs that are apparently reused.
(d) While collecting this sample, one of the Officers stated that several weapons had been placed on the table a few days prior.
(e) These vehicles had cloth seats.
(f) A brick and concrete seat with a metallic restraining bar in the Processing Room was sampled.
(g) The table surface in the Youth Office was sampled.
(h) A Detective's desk surface was sampled.
Any Districts or Areas that were not listed had samples that were devoid of three component primer particles. Any value not listed is zero. There are no Tactical Offices in the Detective Areas, hence the shaded boxes.

TABLE 4—*Load factors (particles/mm^2) for vehicles tested.*

District	Squad car	Squad roll	Tactical car	District	Squad car	Squad roll	Tactical car
1	0.44	2.03	0.11	13	0.59	3.90	2.92*
2	0.68	0.86	0.94	14	0.60	4.99	1.03
2	0.79			15	0.60	4.19	0.83
3	0.52	1.66	0.32	16	0.30	4.28	2.54*†
4	0.36	0.95	0.39	17	0.58	1.24	0.22
5	0.73	2.57	0.10	18	0.96	0.60	0.27
6	0.44	0.92	1.31	19	0.57	3.76	1.25
7	9.62	0.53	0.33	20	0.52	2.69	2.29*†
8	0.26	2.00	0.12	21	0.23	3.30	0.13
8	0.43			22	0.36	1.38	1.81*
9	0.42	1.96	0.84	23	0.07	1.51	0.31
10	0.06	3.27	0.58	24	0.90	2.95	0.94
11	0.75	3.70	0.28	25	2.30*	1.61	0.78
12	0.18	5.04	0.74				

*Vehicles with cloth seats.
†Three component primer particles identified.

When a firearm is discharged, a GSR-rich population of particles is released into the surrounding environment. If GSR testing is to be probative, primary exposure to these particles should be the typical reason that positive GSR test results are obtained and the chances of secondary contamination should be relatively low. In order for a vehicle or detention facility to be a potential source of secondary GSR contamination, a population of GSR particles would need to be available for transfer. Table 1 illustrates that no source of transportation sampled from within the Chicago Police Department possessed such a population of GSR particles to be considered significant. Of the 81 vehicles that were sampled, only two vehicles each showed the presence of a single unique GSR particle. The particles observed from these types of vehicles, even if transferred to the hands of a suspect, would have a limited affect on test results.

Table 2 identifies the common factor of cloth seats in both of the Tactical vehicles in which the unique GSR particles were recovered. Tables 3, 4, and 5 identify the types of vehicles in which high numbers of consistent GSR particles were located. Squad rolls appear to dominate this list and it was recommended that they be avoided in transporting suspects. Suspects would not test positive from being transported in vehicles with high numbers of consistent particles due to the lack of unique particles; although, being in that environment might cause longer analytical times. Based on the comparisons in Table 5, it was recommended that suspects be transported in marked squad cars with vinyl seats.

Table 1 also illustrates that limiting access to table surfaces removes a significant source of potential contamination. Suspects would have to have access to the table surface, have contact with the contamination particles, and have them remain on the backs of their hands until the GSR kit was administered for secondary contamination to occur. The SEM/GSR kits used by the Chicago Police are provided by the Illinois State Police and utilize only right- and left-back sample stubs. Even if the kit collected samples from the palms of the suspect, not allowing the suspects exposure to these surfaces would eliminate the potential for secondary contamination. During training sessions concerning the collection of GSR samples, the collecting personnel were cautioned about contaminating themselves and their kits by coming into contact with table surfaces.

Tables 1 and 2 illustrate that the metallic benches and restraining bars are a limited source of potential GSR contamination. In these locations, the suspect may come in contact with a potential source of unique GSR particles. Again, these particles would have to be present on the backs of their hands before the samples were taken in order for secondary contamination to occur. Unique GSR particles were recovered from six of the 55 benches and bars that were sampled. The sample stubs concentrate the trace materials as they are applied to the surface being sampled. Skin surfaces tend to pick up and lose trace materials as they contact different surfaces. The number of particles collected from benches and bars is insignificant. It was recommended that suspects be detained on the restraining bars until the GSR evidence can be collected.

The reuse of equipment was observed in Area 2 and Area 4. Handcuffs were left on restraining bars and reused to detain suspects in these facilities. Typically, handcuffs are stored between uses that would allow for the normal exchange of trace materials. It was a concern to see this practice at the time the samples were taken. Although unique particles were detected in only one of the samples, it was recommended that the practice of reusing equipment in this manner be avoided.

Re-sampling the two Districts in which several unique particles were initially detected on restraining bars showed that the presence of GSR in these locations is dynamic. Trace materials, including GSR particles, may be deposited and then lost or transferred to other surfaces. No accumulation of unique GSR particles in these facilities was observed, nor was an elevated level of unique GSR particles seen in the repeat sampling.

TABLE 5—*Vehicles compared by seat type.*

Sampled vehicle	Load range
Marked squad cars with vinyl seats (25 sampled)	0.07–0.96
Tactical/Detective's cars with vinyl seats (24 sampled)	0.11–1.31
Tactical/ Detective's/Squad cars with cloth seats (seven sampled)	1.81–3.74
Squad rolls (25 sampled)	0.53–5.04

Conclusions

The use of the SEM/EDS is a widely accepted technique for the identification of GSR. Identification of GSR does not, however, provide information on the mechanism of particle deposit. There is a possibility of secondary transfer of GSR particles to the hands of suspects who have been transported and/or detained in an environment with possible GSR particle contamination. We anticipated and were able to detect potential sources of contamination in both Chicago Police Department vehicles and detention facilities.

The detection of theses sources allowed the following recommendations: transport the suspects in marked squad cars with vinyl seats, avoid transporting suspects in squad rolls or vehicles with cloth seats, do not allow the suspects to come in contact with table surfaces, do not reuse equipment without some maintenance to eliminate the possibility of contamination.

The low numbers of unique GSR particles detected in or on potential contaminating sources suggest that the potential for secondary transfer, although possible, is relatively low.

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