RAIS RESEARCH ASSOCIATION for INTERDISCIPLINARY STUDIES
JUNE 2020

DOI: 10.5281/zenodo.3909951

Persistency of Gunshot Residue in the Head Area. Practical Approach

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ABSTRACT: This paper presents the results of the gunshot residue particles found in the head area of the human body. Information on the persistency and abundance of GSR particles on general population and selected target groups with potential contact to GSR particles or GSR-like particles is still poor. This study was carried out in order to get more information about areas on the suspects were GSR particles are not properly exploitated in the crime scene investigation. The detection and characterization of the GSR particles were performed with SEM/EDS analysis, where elemental composition, surface morphology, particle size and particle population were taken into consideration. Experimental data were obtained from samples collected from different groups of subjects with various occupations. The analytical results were quite surprising and were added to the laboratory database, increasing the quality of the results in the reports given to the court.

KEYWORDS: gunshot residue, firearms, crime scene investigation, GSR particles

Introduction

During the investigation of cases where shooting a firearm is involved, presence of gunshot residue is the main evidence that a person has fired a gun, or had an important role in the firing scene. Lots of studies about the persistence of GSR are focused to establish a connection between the time since discharge and particle deposition. Detection of the gunshot residue (GSR) on the hands of the person involved is accomplished as part of the standard forensic laboratory procedure. Presence and persistence of GSR on the hands of the shooter is an important issue in the cases where the suspect is not sampled immediately after the event has taken place. GSR analysis is performed mainly through scanning electron microscopy equipped with energy dispersive X-ray spectrometer (SEM-EDS).

Several authors have highlighted the fact that the loss of GSR may be due to many reasons such as washing or rinsing hands rubbing them against materials (towels, clothing, etc.), putting them in pockets and handcuffing them behind the back (Jalanti, Henchoz, Gallusser and Bonfanti 1999, 48-52). Since the results obtained by the different authors depended on the experimental conditions, generalizing as to the time factor is not a friend of anyone not even in these cases. The time up to which GSR was detected has been reported to vary between 1 hour, 2 hours, 3 hours, 4 hours, 5 hours, 12 hours, 17 hours, 24 hours and 48 hours. Several studies have also reported that GSR persisted on the hands for a longer period of time in casework than that indicated in laboratory experiments (Zeichner and Levin 1995; Schwartz and Zona 1995). This time limit also depends on the physical activity of a subject after a shooting incident and since a corpse is motionless, activity as a cause of GSR loss is irrelevant. Several authors have reported that the number of GSR particles on the firing hand of a live person decreased rapidly with time. Biggest quantity of GSR particles is lost within the first hour.

The persistence of gunshot residue on shooters' hands found that the amount of barium decreased by a factor of ten in the first two hours of normal activity (Jalanti, Henchoz, Gallusser and Bonfanti 1999, 48-52). Other researchers observed also a quick decrease in the number of particles detected within the first two hours, and reported a notable decrease of GSR particles in samples collected after two and three hours (Brozek-Mucha 2014b, 46-58; Brozek-Mucha 2011). This article describes a study on the loss of GSR when samples were taken at different time periods/intervals after the shooting, and analyzed by scanning electron microscopy through SEM-EDS.

Experimental

Preliminary analysis

In order to establish if the person/suspect who used the gun in an incident, an experiment was carried out to find out if in the oriffices found on the face/head area (nose and ears) are present GSR particles. If the presence is confirmed, the main issue is also to be able to identify the particles distribution by the area/zone where they were found, also the persistence of this particles deposition in a specific period of time, calculated from the shooting moment. For this experiment were used 2 types of ammunition: Glock 9 mm and Carpati 7,65 mm. There were performed 5 series of shootings with each type of ammunition. After the first series of shootings, were collected samples from each subject from the nose area (both nostrils) and from the outer ear area of both ears. The samples were collected using cotton swabs and then transferred on carbon tape, covered with a thin layer of carbon and analysed with SEM coupled with an Oxford Inca energy dispersive X-Ray spectrometer, in secondary electron mode, 20 kV accelerating voltage.

Main study

The series of shootings were carried out in the indoor shooting training chamber from the Police, especially designed for such activities (Schwoeble and Exline 2000). The weapons used were a Glock caliber 9 mm semi-automatic pistol and Carpati caliber 7,65 mm ammunition used is listed in Table 1. The whole experiment was repeated to produce five sets of data. The test person loaded and fired 5 cartridges holding the gun with both hands. Loading and firing were carried out by the same person, so that skin retention of particles remained the same. The barrel was cleaned with a specific cleaning solution before each shot.

The external surface of the weapons was cleaned also. After firing each type of ammunition, the weapon was completely dissembled and cleaned. Sampling was carried out immediately after the first test firing, 8 hours after the second test firing, 16 hours after the third test firing, 24 and 48 hours after the fourth test firing and after 72 hours after the fifth test firing. The subject of testing was instructed to continue his normal activity in office or outside, in areas that were not exposed to GSR contamination. The main condition was to not wash his face or ears. Samples were collected from the both nostrils and both outer ears using cotton swabs and then transferred to 12 mm carbon double adhesive SEM stubs specially designed for GSR collection and packed in kits of five pieces. Each stub was dabbed repeatedly with the swab until stickiness of the surface became ineffective.

A blank sample test stub was activated and exposed to the ambient air during the sampling (Brozek-Mucha 2009, 33-44; Brozek-Mucha 2014a). The analysis was performed with a fully automated scanning electron microscope (SEM), in backscattered electron (BSE) mode, with an automated stage and an energy dispersive X-ray spectrometer (EDX), controlled by a software specially developed for GSR analysis.

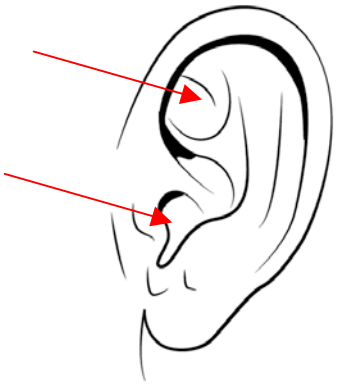

Figure 1. Outer ear areas of interest for GSR sampling

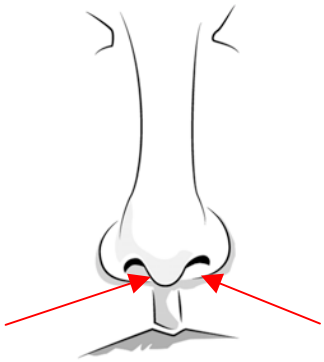

Figure 2. Nose areas of interest for GSR sampling

Main study SEM-EDS analysis

SEM-EDS analysis was focused on particles that had the elemental combinations shown in Table 2 and 3. Only unique and characteristic particles were counted in the identification of the GSR, environmental particles have no value as a proof (Zeichner and Levin 1995; Jalanti, Henchoz, Gallusser and Bonfanti 1999, 48-52; Schwoeble and Exline 2000). The particle population distribution on the right and left nostrils and right and left outer ears of the test persons is shown in Table 1. In addition to these results, no GSR was detected when sample tests of non-exposed subjects were analyzed.

Table 1. The persistency of GSR particles

Type of ammunition	Type of analysis	Number of series/shots	Type of surface	Period of persistency
Glock 9 mm	SEM/EDS	5/1	nostrils	up to 48 h
			outer ear	up to 72 h
Carpati 7,65 mm	SEM/EDS	5/1	nostrils	up to 40 h
			outer ear	up to 48 h

Table 2: Distribution of particles on samples for Glock 9 mm

INCA_GSR (elemental combinations)	Samples - Glock 9 mm			
	right ear	left ear	right nostril	left nostril
SbBaPbSn	-	-	-	-
SbBaPb	25	22	40	48
SbPbSn	-	-	-	-
SbBaSn	-	-	-	-
SbBa	132	124	150	115
BaPb	81	89	104	95
SbPb	53	48	73	76
CuZn	308	277	184	195
Pb	297	256	249	264
Fe	206	187	311	335

Table 3. Distribution of particles on samples for Carpati 7,65 mm

INCA_GSR (elemental combinations)	Samples - Carpati 7,65 mm			
	right ear	left ear	right nostril	left nostril
SbBaPbSn	-	-	-	-
SbBaPb	37	29	45	42
SbPbSn	18	12	17	11
SbBaSn	6	9	8	12
SbBa	120	109	107	133
BaPb	93	101	72	80
SbPb	87	75	90	77
CuZn	374	302	263	224
Pb	410	385	298	406
Fe	391	402	369	444

Discussion and results

Different results were noticed in the number of the GSR particles detected. This showed big variations from one shot to the other. The quantity of particles found during analysis varies pretty much in controlled laboratory tests, but not in a major manner that could affect the interpretation of the results obtained. After the first series of shots was found the biggest amount of GSR collected from outer ears and nostrils. Results varied without prediction because of the loss and transfer of the particles during time and activities taken. These observations were constant for all the subjects involved in the study.

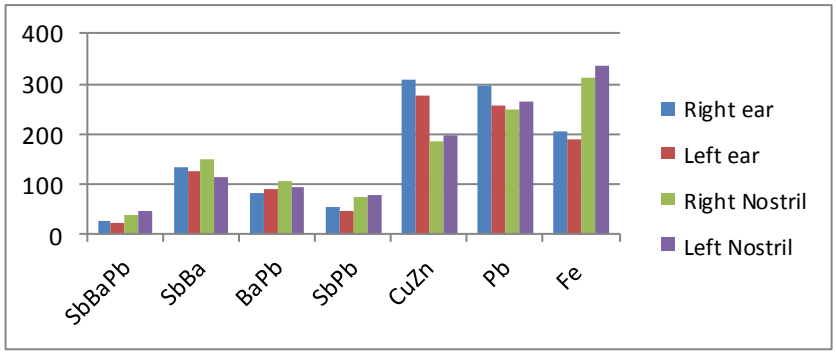

Figure 3. Occurrence of elemental combinations of particles in Glock 9 mm samples

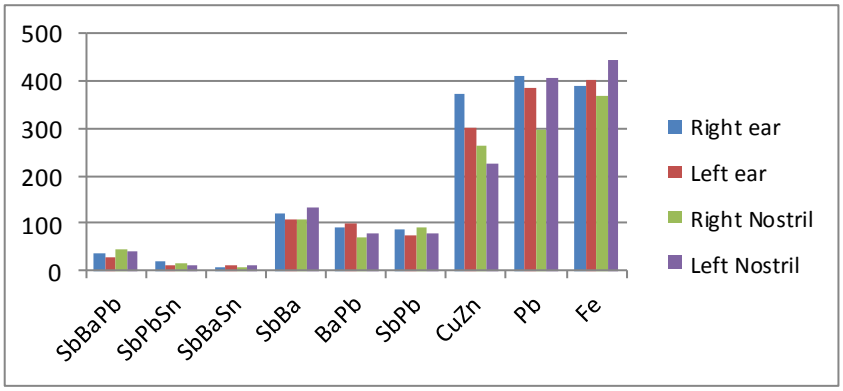

Figure 4. Occurrence of elemental combinations of particles in Carpati 7,65 mm samples

The environment where you find the GSR particles is proved to influence its persistence through time. The amount of GSR particles on hands and other surfaces also vary depending the firearm and type of ammunition used. Even in difficult cases GSR particles can still be detected on classical samples in the interval of 2 to 24 hours post discharge. Also, it is known that the density of GSR particles left after discharge depends on the type of ammunition used and the dispersion of the particles into the environment after discharge varies depending of the type of firearm/weapon used. In figures 3 and 4 you can see that the amount of GSR particles formed is different for the 2 types of ammunition and guns in this case also, though these are samples collected from outer ears and nostrils (Brozek-Mucha 2011). We can observe the fact that the distribution and density are similar, which makes them more than viable for current sampling methods in shooting/use of firearms cases. Also the longer period of time suitable for detection of GSR particles remained after discharge is the main criteria in opting for these areas first for collection of evidence because of the low contamination rate. Sampling with swabs from the outer ears and nostrils of the shooter proved to be beneficial but not the best. This is why we started developing a new device for a proper collection of GSR particles from this type of orifices. More information about this new device will be revealed in the next article.

Conclusions

Persistence of GSR particles decreases very rapid after discharge takes place. In classic conditions it was highlighted that it can be detected on the hands of the shooter in an interval of 1 up to 6 hours hours. In exceptional cases the longer period was 24 hours. In this study it was proved that the remaining period for GSR particles increases dramatically when collected from outer ears and nostrils. Also the contamination rate is minimum. This is why we consider that these results will be very useful for the forensic community and the justice providers. The analytical results were quite surprising and were added to the laboratory database, increasing the quality of the results in the reports given to the court. The study was extended for more ammunition and firearms types. The results will be published soon.

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