CASE REPORT

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Nondestructive Recovery and Examination of Bullet Fragments from Brain Tissue

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ABSTRACT: A technique providing both analytical and toolmark results for lead fragments from bullets is discussed. It permits the nondestructive recovery of bullet fragments from soft cadaver tissue and was used with a plasma asher in an actual homicide case. The lead fragments are examined by neutron activation analysis (but other analytical techniques can be used) for their antimony and arsenic content and by microscopy for matching toolmarks.

KEY WORDS: criminalistics, ballistics, chemical analysis

The nondestructive recovery of bullet particles from soft cadaver tissue can be important. If sufficient particles are found, the caliber can be estimated, toolmarks can be compared with test bullets, the physical makeup of the bullet can be determined, and the composition of the bullet can be compared with cartridges found in the possession of a suspect. Since the amount of antimony, arsenic, copper, and other metallic constituents of bullets varies with the manufacturer, the composition may indicate the source [*1-7*].

Case Report

In a recent case received by this laboratory, the autopsy report showed that a homicide victim had suffered multiple gunshot wounds of the body from a .30-30 caliber rifle. The victim also sustained a gunshot wound of the head. An entry wound located in the roof of the victim's mouth indicated the bullet traveled upward and to the left rear of the head, penetrating the brain. This projectile did not cause an exist wound in the skull. Cranial X-rays showed a concentration of particulate matter in the brain near the top of the skull (Figs. 1 and 2). Initially it was thought that this bullet was lost or overlooked during transport of the body from the scene of the shooting, but close examination of the X-ray indicated that the bullet fired into the victim's mouth had possibly disintegrated upon

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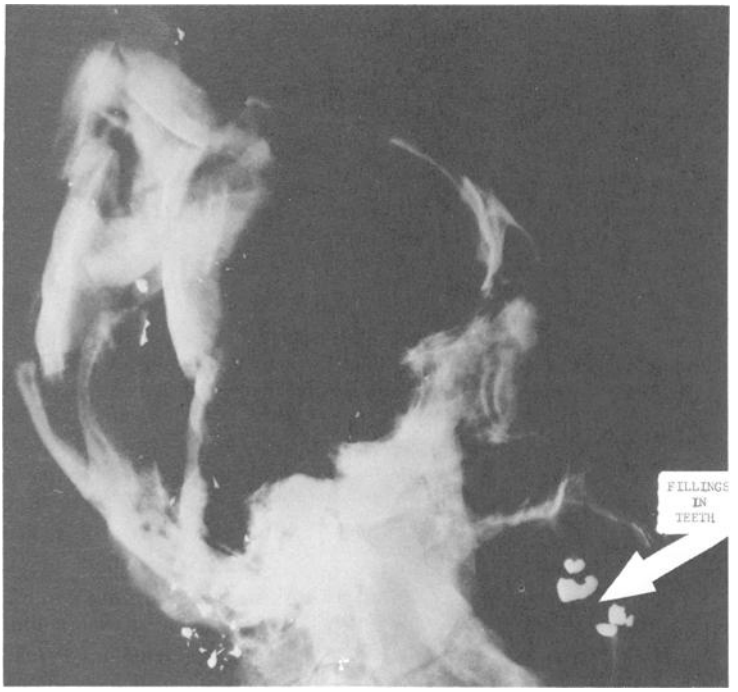

FIG. 1—*Cranial X-ray with bullet fragment.*

FIG. 2—*Brain tissue with bullet fragments.*

entering the brain. To the coroner this was unusual since .30-30 caliber bullets had caused all the other wounds and this caliber bullet would not be likely to disintegrate under the circumstances. During the course of the investigation two suspects were accused and indicted. One of the co-defendants had a .30-30 rifle and the other a .22-250 rifle. Before the trial the possessor of the .22-250 rifle elected to turn state's evidence. He stated to authorities that he had fired with his .22-250 rifle at the victim's head only when she was dead or near death. To substantiate this claim, the body of the victim was exhumed and the top portion of the skull, complete with brain, was transferred to the laboratory.

Experimental Procedure

Aseptic techniques were used to remove the brain from the skull; it was carefully sectioned, and the sections were dried at 110°C for 24 h in a convection oven placed in a fume hood. The fume hood was necessary to remove noxious odors generated during this procedure. This procedure resulted in irregular sizes of brain material that were spread on several Polaroid 52 film sheets. Radiographs were recorded with a Faxitron field emission X-ray Model 805.

Inspection of the irradiated film indicated which pieces contained metallic fragments and these were removed. The remaining pieces were radiographed again to see if any containing metal had been missed. Those that indicated metallic inclusions were heated in a muffle furnace for 6 h at 300°C to remove low-ashing carbonaceous material. This temperature is below the melting point of lead. After cooling, the pieces were transferred to glass plates for treatment in an oxygen plasma furnace (asher).

The asher is commercially available (Series 1000 Plasma System by International Plasma Corp.) and consists of two cylindrical sample chambers (or reactors), a radio-frequency (RF) generator, and a vacuum pump fitted with a cold trap [8]. The ignited brain material with metallic inclusions was placed in the sample chambers. The chambers were sealed and evacuated to a pressure of approximately 13 Pa (0.1 torr). In the process oxygen was introduced slowly and excited by RF energy. The excited oxygen or plasma attacked the oxidizable materials present, and the resulting gaseous by-products were continuously removed from the chambers by the vacuum pump. No external heating was necessary, and oxidation proceeded at a temperature based on the proper setting selected, in this case about 150°C.

After about 12 h, the plates were removed and the pulverized material was placed in a small ultrasonic bath with deionized water. About 30 s of vibration freed the metallic particles and concurrently dissolved most of the powder. The metallic particles (lead and pieces of copper jacketing) were removed and weighed. These particular fragments were, however, unsuitable for toolmark comparison.

The recovered bullet fragments, bullet exemplars associated with the defendants, and antimonial lead standards were analyzed by neutron activation analysis for arsenic and antimony content. The fragments, exemplars, and standards were weighed, placed into numbered polyethylene vials, and irradiated for 10 min at a thermal neutron flux of 5×10^{13} n/cm^2·s in the research reactor at the National Bureau of Standards. A 4096-channel pulse height analyzer was used in conjunction with a 60-cm^3 lithium-drifted germanium (Ge [Li]) detector for spectrometric measurements. Peaks having energies at 564 and 603 keV for ^{122}Sb and ^{124}Sb, and 559 and 657 keV for ^{76}As were monitored.

Table 1 shows the concentrations of arsenic and antimony calculated from the data.

The different caliber bullets show different antimony and arsenic contents, whereas the fragments do not. Very good agreement is shown between the antimony content of the .22-250 bullets and the fragments recovered from the brain, thus substantiating the statement of the suspect who claimed he had fired at the victim's head when the victim was dead.

TABLE 1—*Percentage of antimony and relative counts for arsenic.*

Samples	Antimony, %	Arsenic, cpm/g[a]
Nose, .22-250[b]	2.3	186 000
Base, .22-250[b]	2.3	174 000
Nose, .30-30[b]	0.5	not detected
Base, .30-30[b]	0.5	not detected
Recovered fragments		
Fragment 1	2.3	186 263
Fragment 2	2.3	186 422
Fragment 3	2.3	186 000

[a] Because the standards used for comparison had no certified arsenic content, counts per minute per unit weight were compared.

[b] Sampling was done at the nose and at the base on each of two bullets and the percentage of antimony determined was averaged.

Discussion

Intact bullet fragments may be recovered from soft tissue without subjecting the fragments to mechanical deformation from fluidizers or homogenizers. Also, small particles that may be overlooked by other techniques can be recovered. Because knives or high-speed blades do not have to be used, valuable evidentiary material can be recovered for possible matching of samples and determination of physical makeup; in addition, the fragments may be examined by neutron activation analysis, X-ray spectrometry (wavelength or energy dispersive), emission spectroscopy, or atomic absorption.

Outcome

The written report of the analysis of bullet fragments indicating the correlation between the unfired bullets and bullet fragments from the brain enabled the investigators in this homicide case to develop state's evidence from one of the two defendants. The case was successfully prosecuted without the need for court testimony by a scientific expert on the analysis.

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