

Case reports

Intensive gunshot residues at the exit wound: an examination using a head model

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Summary. The autopsy findings of intensive gunshot residues at the exit wound after a gunshot wound in the head led to an experimental investigation to clarify the mode of origin and intensity of these gunshot residues on the inner surface of the exit wound. For this purpose a simple skull/brain model was prepared. The results of the examination showed that with weapons of the same calibre distinct gunshot residues should be expected at the exit wound.

Key words: Shooting injuries – Exit wound – Gunshot residues

Zusammenfassung: Der Sektionsbefund einer intensiven Beschmauchung am Ausschuss eines Kopfschusses war Anlaß, Art und Intensität der Anschmauchung an der Innenseite des Schädels im Ausschussbereich experimentell zu überprüfen. Dabei wurde ein einfaches Schädel Hirn-Modell eingesetzt. Die Versuchsergebnisse zeigen, daß bei Verwendung gleichartiger Waffen mit einer deutlichen Beschmauchung am Ausschuss zu rechnen ist.

Schlüsselwörter: Schußverletzungen – Ausschuss – Schmauch

Introduction

The presence of gunshot residues at the exit wound is medical evidence that needs to be clarified, because from this the angle and direction of firing can be identified. A specific case gave rise to an experimental examination.

Case Report

A 32-year-old man had a quarrel with his girlfriend, during which she was shot with a muzzle-loading gun and suffered a serious wound to the chest. In spite of this she

managed to escape to a neighbouring apartment. The man kicked the house door and then the living-room door open and tried unsuccessfully to push his girlfriend from the balcony. He then returned home to fetch the weapon, during which time the young woman barricaded herself in the bedroom. The man also managed to break in here and a shot was heard by the neighbours. Immediately afterwards the woman came out of the room with the weapon in her hand. The man was found dead in the bedroom with a head wound. A bullet hole was found in the ceiling together with a totally deformed lead bullet. The woman offered no explanation of the events.

Autopsy findings

The skull showed severe damage to the left temple with a large bullet cavity and encephalotomy. A typical “exit defect” was found in the right temple. Several calvarial fragments were present one of which showed a funnel-shaped expansion outwards. In the inner part of the defect a gunshot residue ring approximately 2 cm in diameter was found. Gunshot residues were also present on the rim of the groove-shaped exit wound of the scalp. Scattered gunshot residues were present on the back of the left hand on the webbed skin between the thumb and the forefinger and striated residues were present on the forefinger and thumb (shooting hand). On the webbed skin between the thumb and forefinger of the right hand intense smoke trails were also found (holding hand). The woman’s hands were not examined in the hospital.

Technical data

The gun used was a Tingle pistol (Robert Tingle, 1960, Tingle Manufacturing Company, USA), calibre .44. Proved: Gardone 1979, barrel 220 mm. Trigger pull weight: 15 N (newtons). The single-shot percussion pistol with rifled barrel was developed in the 1950s and has an old-fashioned appearance. It is presently produced in Italy.

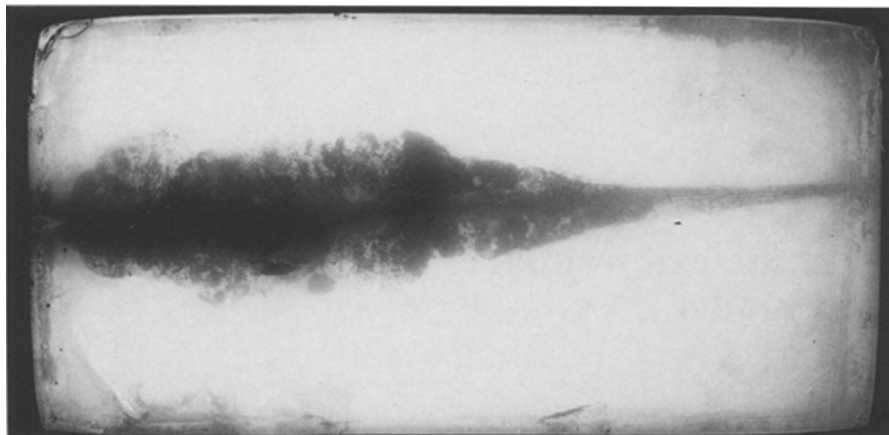


Fig. 1. Gelatine block (15 × 15 × 30 cm) after gunshot experiments with a gunpowder cartridge and a round lead bullet. The entrance of the bullet is on the left

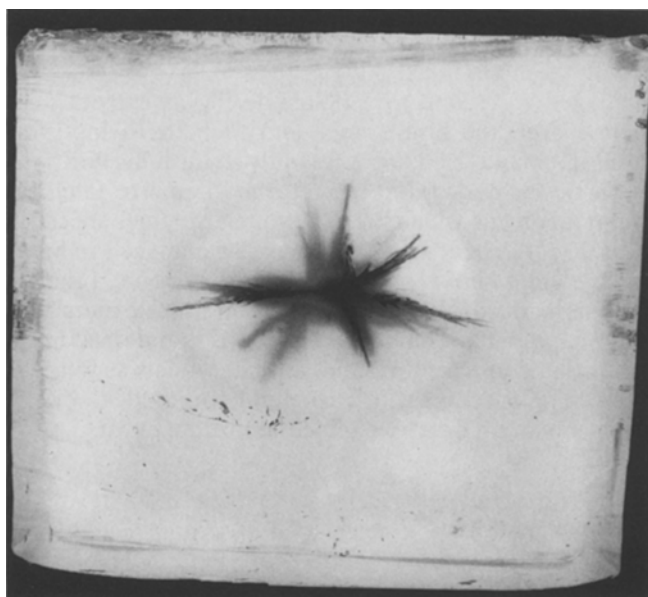


Fig. 2. Fissure line in the gelatine block with surrounding circular marking of the dilatation of the temporary cavity

The following gun accessories were found in the apartment:

- Pressed black powder pellets for calibre .44, weight approx. 1.7 g.
- Lead bullets for calibre .44, weight approx. 8.6 g.
- Long bullets (Minié) for calibre .44, weight approx. 19.6 g.

A shooting test with the weapon revealed the following average values using the round lead bullets and the pressed black powder pellets ($n = 8$):

- Velocity $V_1 = 70$ m/s
- Bullet energy $E_1 = 21$ Joule

Using the long bullets ($n = 2$) the following values were obtained:

- Velocity $V_1 = 97$ m/s (71–124 m/s)
- Bullet energy $E_1 = 76$ Joule (49–151 Joule)

The gunshot residues found on the shooting hand were in accordance with the medical evidence.

Method

Gelatine blocks [1, 2], measuring 15 × 15 × 30 cm, were used as targets to reconstruct the smoke evidence found on the skull. The gelatine mixture consisted of 250 g fine gelatine in 1000 ml water. The impact pattern of the bullet is shown in Figs. 1 and 2. To demonstrate the smoke trails at the exit wound a skull/brain model was additionally used. The shape of the skull was simulated by means of double plaster bands (0.5 cm thick), originating vertically from a wooden plate which had the dimension of the horizontal “saw cut surface” of the skull thus forming an oval cylinder 15 cm high. A plastic bag was placed on the inner surface of the cylinder thus imitating the cerebral membrane and also preventing leakage from the cylinder, which was then filled with gelatine (125 g/1000 ml water). Finally, a 4 mm plastic lid was placed on top of the cylinder thus serving as the “scalp”. To achieve a reasonable inside pressure, a 5 kg weight was placed on top of the “scalp”.

Results

The results of the shooting experiments with five models (see Table 1) are summarized below:

1. When the muzzle of the gun was placed close to the skull (see Figs. 4–6), smoke traces were present at the entrance wound (outside panel) of the model, which showed a similar dilatation of the inside panel of the exit wound.

Table 1

Shot no.	Distance (mm) muzzle/model	Diameter (mm) of gunshot residues at entrance wound		Diameter (mm) of gunshot residues at exit wound	
		Outside	Inside	Inside	Outside
1	10	100	20	20	Absent
2	0	35	50	35	Absent
3	0	33	40	35	Traces
4	10	86	25	25	Traces
5	100	130	20	Traces	Absent

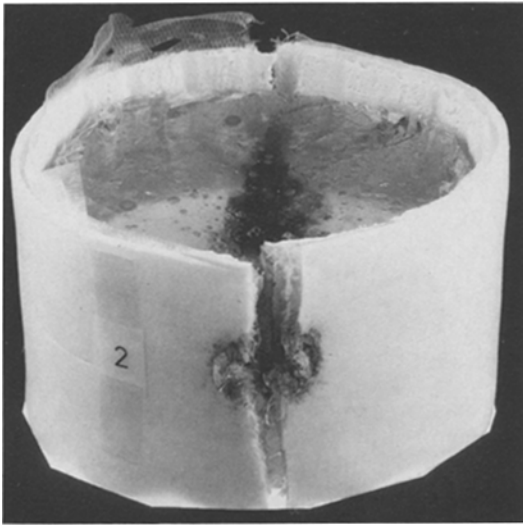


Fig. 3. Shooting experiment showing a shot passing completely through the head model

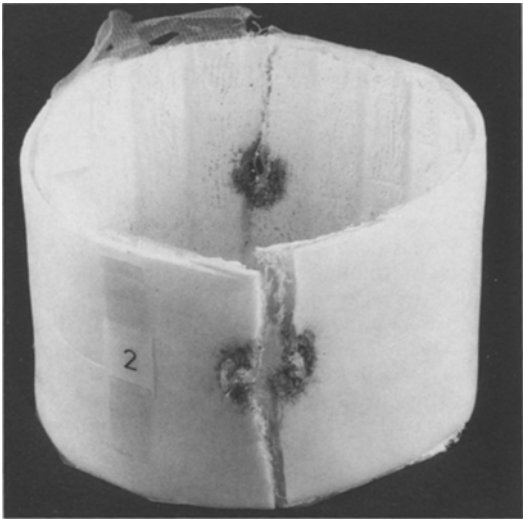


Fig. 4. Shooting experiment 2: “skull model” after removal of the “brain” (gelatin): gunpowder residues at the entrance wound (outside) as well as the exit wound (inside)

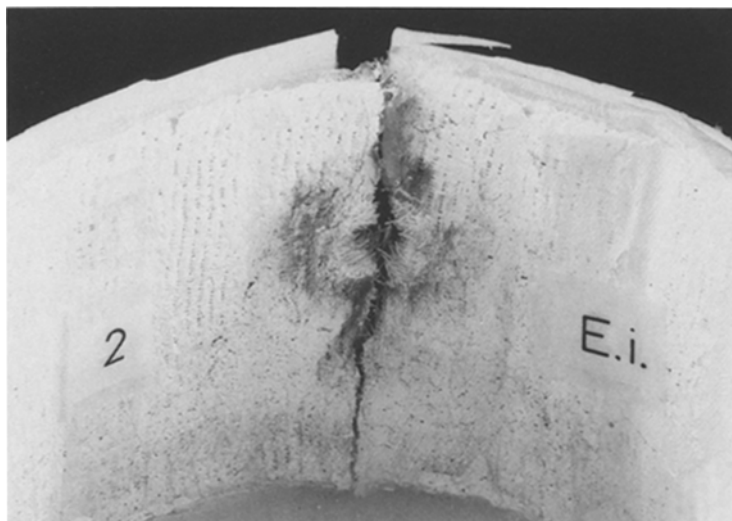


Fig. 5. Shooting experiment 2: gunpowder residues at the entrance wound (inside = *E.i.*)

2. The track of the bullet (bullet hole) and the dilatation of the temporary cavity were marked by means of optically clear protruding gelatin fissures (see Fig. 7).
3. The skull model was destroyed, the plaster bandages splitting in a vertical line in most cases (see Figs. 3 and 4).

Discussion

The experimental reconstruction of the skull/brain model with the weapon in question revealed clear gunshot residues at the exit wound, similar to those detected on the victim. The amount of the propelling charge of black powder expelled from the large calibre weapon led to the transport of burned and unburned particles throughout the track of the bullet as far as the exit wound. The presence of gunshot residues at the exit wound on the inside of the skull even at a shooting distance of 10 cm can be explained, at least to some degree, by the loss of particles from the lead bullet by the Vinogradov phenomenon [3]. Kijewski and Kampmann [4] also reported the presence of gunshot residues on the outside of the exit wound between skull and scalp. Using modern revolvers or pistols of equal calibre, comparable results could not be demonstrated with regard to smoke particles at the exit wound.

Similar “ballistic structure models” made of bone and gelatine were used by Missliwetz and Wieser [5]. These were considered to be more accurate, because with this design the precise test conditions can be reproduced more exactly.

The distribution of skull and bullet fragments shown by X-ray analysis can provide important clues to the direction of the shot [1]. The dilatation of the bullet track and (temporary) cavities in the head were examined intravitaly by means of computer tomography and compared with the results of the autopsy findings [6]. This method is recommended as an appropriate supplement to neuropathological and forensic findings.

Similar results can also be obtained with this skull/brain model, although there are important differences. The model used could be classified as an “open system”

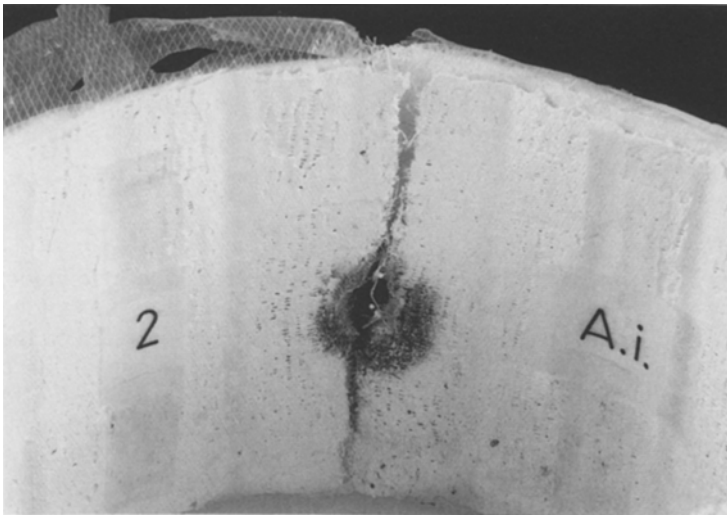


Fig. 6. Shooting experiment 2: gunpowder residues at the exit wound (inside = A.i.), detailed photograph

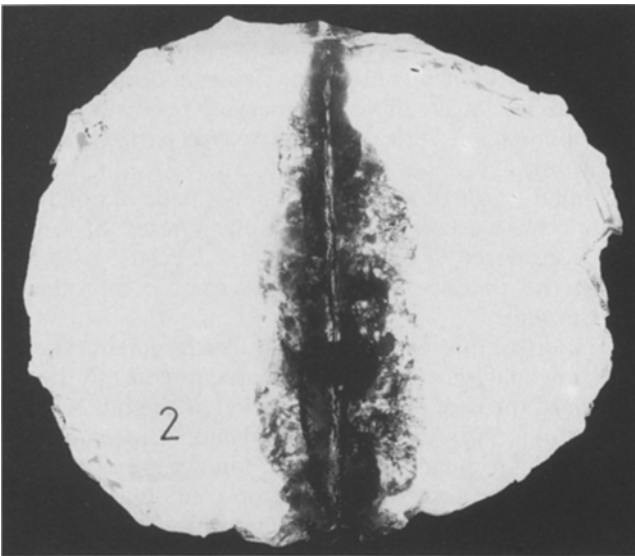


Fig. 7. Shooting experiment 2: bullet track and temporary cavity in the simulated brain tissue (gelatin)

and a normal skull as a “closed system”; differences in compressive stress and diameter of the temporary cavities will result. This skull model therefore does not completely reflect the real situation.

As a result this model is only suitable for establishing the essential components of shooting injuries to the head, but it can be concluded that black powder from the propelling charge must be expected at the exit wound when relatively large calibre guns are used.

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