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ORIGINAL ARTICLE

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# Backspatter from experimental close-range shots to the head

## II. Microbackspatter and the morphology of bloodstains

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**Abstract** Backspatter is the ejection of biological material from a gunshot entrance wound against the line of fire. Backspatter of blood was investigated experimentally in transverse gunshots to the heads of calves ($n = 9$) from shooting distances of 0–10 cm. The resulting bloodstains were documented on white paper placed horizontally 60 cm below the impact site. The morphology of bloodstains and the distribution of microstains (diameter < 0.5 mm) is reported. The number of microbackspatter stains per gunshot varied between 39 and 262 and the maximum travelling distance was 69cm while the vast majority of microdroplets accumulated between 0 and 40cm. The direction a single droplet can take comprises every possible angle between the most tangential ones to the skin surface. Microstains exclusively were circular to slightly oval. The morphology of macrobackspatter stains (diameter > 0.5 mm) varied from round to elongated with circular, droplike and stains in the form of exclamation marks predominating. Small macrostains (0.5–4 mm) made up more than 90% of the macrostains and no systematic relationship between distance travelled and size of the stains could be established. The necessity of appropriate lighting and magnification in the investigation of surfaces for backspatter is stressed because many microstains are located in the proximity of the entrance wound where the firearm and the shooting hand are located in cases of close-range shots.

**Key words** Backspatter · Blood stain morphology · Close-range shots to the head · Gunshot wounds · Reconstruction

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## Introduction

Backspatter of biological material ejected from the entrance wound against the line of fire has been described in case reports (e.g. Weimann 1931) and studies investigating shooting hands or firearms used for suicides (e.g. Brüning and Wiethold 1934; Zwingli 1941; Stone 1992; Betz et al. 1995). In a previous publication (Karger et al. 1996), the distribution and dynamics of macrobackspatter of blood from close range shots to the heads of calves was reported. In every gunshot, so-called primary backspatter occurred, i.e. the droplets originated from the entrance wound one to a few milliseconds after impact of the bullet and hit the target surface (paper) directly. In three out of nine gunshots, secondary backspatter additionally exited after a short time interval of less than one second in the form of a momentary swell of blood. This blood hit the target surface below the entrance wound, thus creating secondary droplets. Macrobackspatter (stain diameter > 0.5 mm) was differentiated from microbackspatter (stain diameter < 0.5 mm) for practical and analytical reasons. The distribution of this microbackspatter and the morphology of bloodstains will be analysed in this report.

## Materials and methods

The detailed experimental set-up is described in the companion-paper (Karger et al. 1996). Briefly, live New Jersey calves ($n = 9$) destined for slaughter were shot into the right temple perpendicular to the skin surface with a 9 mm SIG P210 pistol. Two different kinds of ammunition were used: 9 × 19 mm Parabellum (= Luger) full metal jacket (FMJ) rounds (AMA) and 9 × 19 mm Parabellum Action-1 rounds (solid copper-alloy with a deformation well, Dynamit Nobel AG). Each type of bullet was fired from four different distances (see Table 1). The gunshots were followed by complete autopsies of the heads.

The resulting backspatter was documented on thick white paper placed on the ground 60 cm below the impact site. After each gunshot, the paper was collected and examined in the laboratory. The size of the stains was determined by their diameter. In lengthy stains, the largest diameter was recorded. Microbackspatter was defined as stains with a largest diameter of less than 0.5 mm. Stains which had a diameter of less than 0.1 mm were not clearly visible with the naked eye and were thus not included in the quantitative analysis.

**Table 1** A summary of ballistic parameters and results for all nine gunshots. The * indicate the three gunshots involving secondary backspatter. The number of macrostains is given for comparison

| Gunshot | Ammunition | Shooting distance | Number of microstains | Max. travelling distance (cm) | Number of macrostains |
|---|---|---|---|---|---|
| 1 | FMJ | Tight contact | 187 | 54 | 324 |
| 2 | A-1 | Tight contact | 53 | 43 | 41 |
| 3 | FMJ | Loose contact | 126 | 64 | 51 |
| 4 | A-1 | Loose contact | 69 | 37 | 31 |
| 5 | FMJ | 5 cm | 262 | 69 | 99 |
| 6 | A-1 | 5 cm | 39 | 31 | 46 |
| 7 | FMJ | Tight contact | 117* | 38 | 133* |
| 8 | FMJ | 10 cm | 141* | 53 | 305* |
| 9 | A-1 | 10 cm | 1370* | 62 | 478* |

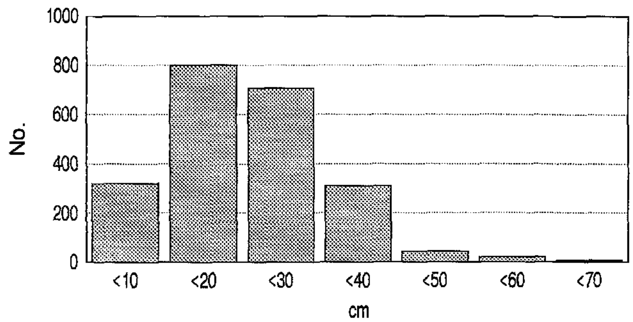


**Fig. 1** The travelling distances of primary and secondary microstains in all nine gunshots

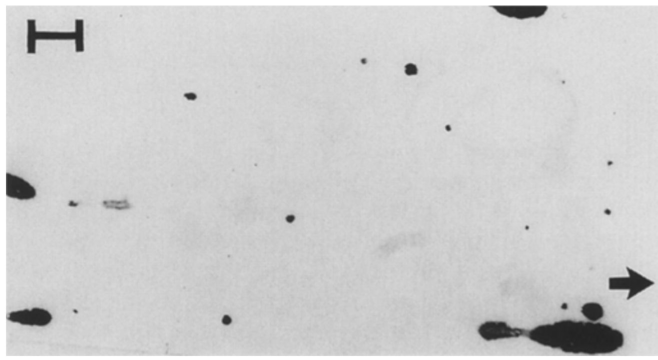

**Fig. 2** Primary bloodstains on the paper target about 15cm from the entrance wound in gunshot No. 1 (tight contact, FMJ). The bar indicates 1mm, the arrow indicates the direction of the location of the entrance wound. The smallest stains could not be recognized with the naked eye

## Results

The number of microbackspatter stains per gunshot varied between 39 and 262 for primary backspatter and between 117 and 1370 for the three gunshots with additional secondary backspatter (Table 1). The number of stains from micro- and from macrobackspatter appear to have a weak positive correlation (Table 1). The maximum travelling distance of primary microbackspatter was 69 cm while the vast majority of droplets accumulated between 0 and 40 cm (Fig. 1). The distribution of primary stains in front of the entrance wound covered every angle within a semicircle while secondary stains were located around the impact site on the paper.

The size of stains from microbackspatter ranged from minute (invisible with the naked eye) to 0.5 mm in diameter (Fig. 2). Their morphology showed little variation with tiny circular to slightly oval stains being found exclusively (Fig. 2). So a quantitative analysis of the stain morphology was done for macrobackspatter only and the number of stains increased with decreasing size. Small primary macrostains (0.5 mm–4 mm) made up more than 90% of all stains (Fig. 3). No systematic relationship between the distance travelled and the size of the primary stains could be established (Fig. 3). The shape of the primary stains varied from round to elongated with circular, drop-like and stains in the form of exclamation marks predominating (Table 2). The frequencies of the different shapes of the primary stains did not change with the travelling distance (Fig. 4). For example, the proportions of

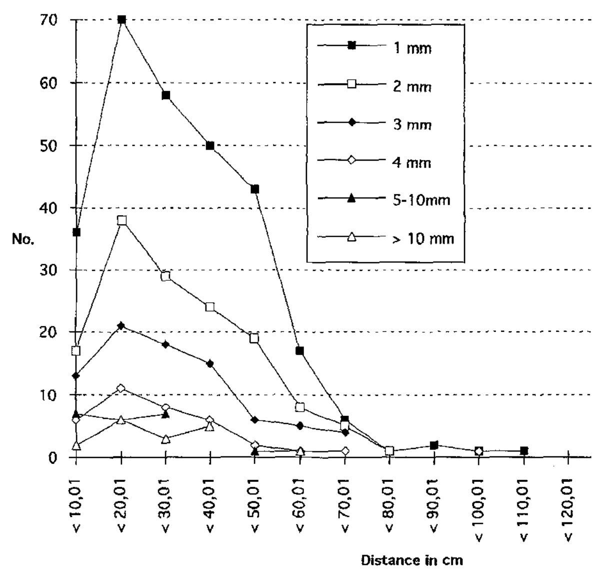


**Fig. 3** Primary macrostains: the relationship between the travelling distances and the size of the primary macrostains in the six gunshots exclusively involving primary backspatter

circular and exclamation mark forms were similar between 0–10 cm and between 50–60 cm. The elongated forms were exclusively pointing towards the entrance wound but sometimes the projected line through their

**Table 2** Primary macrostains: the total numbers of the bloodstain shapes from the six gunshots which exclusively produced primary backspatter

| Circular | Oval | Drop form | Crown form | Exclamation mark form | Irregular |
|---|---|---|---|---|---|
| 178 | 43 | 125 | 30 | 199 | 17 |

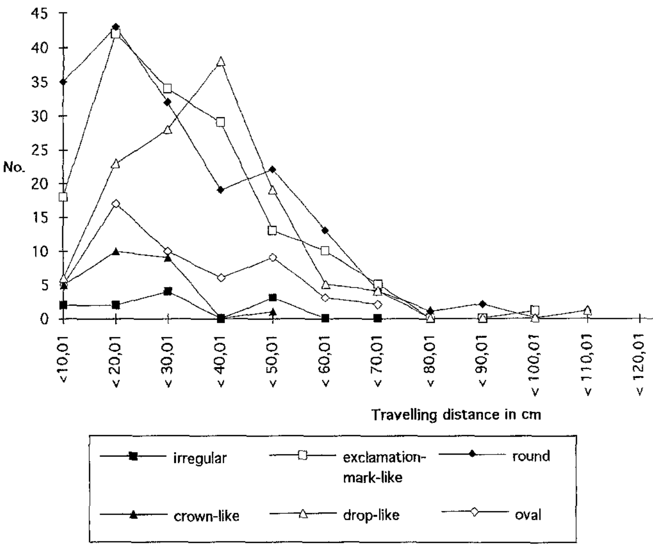


**Fig. 4** Primary macrostains: the relationship between the travelling distances and the shapes of the primary macrostains in the six gunshots exclusively involving primary backspatter

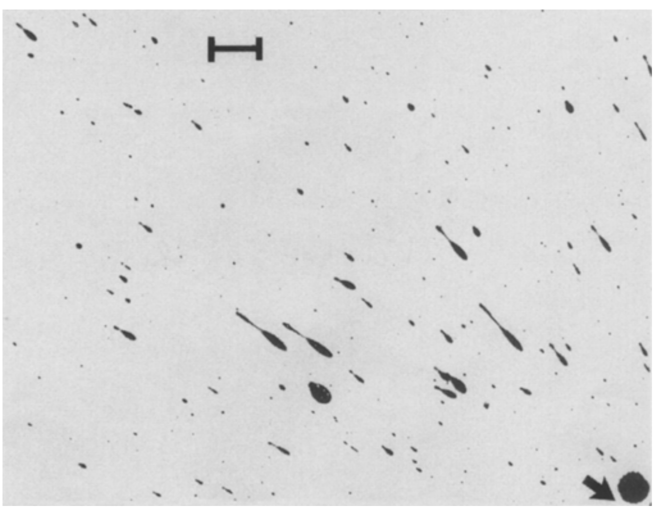

**Fig. 5** Primary bloodstains on the paper target in gunshot No. 1 (tight contact, FMJ). The bar indicates 1cm. The entrance wound was located 13cm diagonally from the lower right corner (arrow). Note that projected lines through the lengthy stains do not converge exactly at one point

long axis missed the entrance wound by a few centimeters (Fig. 5). The stains from secondary backspatter surrounded the impact site of the swell of blood on the paper with exclamation mark forms oriented exactly in line with the impact site clearly predominating.

## Discussion

The smaller brain volume and in particular the wider subcutaneous space in the head of calves render a quantitative comparison with man difficult but the quality of the experimental backspatter is certainly similar to man (Karger et al. 1996). Microbackspatter of blood occurred with every experimental close range shot to the head. The number of stains from primary microbackspatter per gunshot varied but was considerable and outweighed the number of the more obvious stains from primary macrobackspatter in four out of six gunshots (Table 1). The short distance travelled by primary microbackspatter results in a dense aerosol or spray in front of the entrance wound. This dense aerosol covered a hemisphere or a semicircle (on the two-dimensional paper) and was essentially restricted to the area where the firearm and the shooting hand/arm are located in the case of close range shots. Therefore, the investigation of a firearm, a hand or clothing for backspatter should not be restricted to a macroscopical search for the more obvious stains from macrobackspatter. Even if macrostains are not readily visible, some microstains might be present. Thus, the detection or exclusion of stains from microbackspatter in practical case work necessitates magnification and appropriate lighting or chemical analysis, especially if the tiny stains do not contrast with the background, e.g. dark-coloured firearm or clothing.

The stains from microbackspatter were exclusively circular or slightly oval in shape. The high surface tension of the tiny microdroplets may have counteracted deformation during angular impact. Or the low mass/sectional density of microdroplets, which lead to rapid deceleration in free flight, resulted in impact angles close to 90° because by then, gravitation was the major factor acting on the droplets. The shape of the macrostains, on the other hand, showed every variation from circular to exclamation mark forms. So their angle of impact can be determined from the ratio of the length and width (e.g. MacDonell 1982; Brinkmann et al. 1986). Elongated primary macrostains could always be projected back to their point of origin but sometimes the projected line through the long axis of the stain missed the entrance wound by a few centimeters (Fig. 5). This can be explained by turbulence inside the backwards stream of escaping muzzle gases deflecting the path of the droplets (Karger et al. 1996) and by the gases ricocheting from solid surfaces such as the weapon.

Initially, it was surprising to find that no correlation between the size and the travelling distance of the droplets could be determined. Backspatter of blood is produced by the subcutaneous gas pressure and additionally by intracranial overpressure and tail splashing (Karger et al. 1996). These are not static phenomena but change continuously with the lapse of time and at different locations. Consequently, different kinetic energies are transferred to individual droplets. This results in droplets of similar size/mass exiting with different initial velocities, as verified previously (Karger et al. 1996). Furthermore, the angle of exit from the entrance wound (upwards/downwards) also greatly influences the travelling distance of droplets. A positive correlation can only be detected when macrobackspatter is compared with microbackspatter. The very low sectional density of microdroplets results in massive deceleration due to air resistance.

So in conclusion, the investigation of surfaces for backspatter should be carried out with magnification and appropriate lighting because a large number of microstains is concentrated in close vicinity of the entrance wound where the firearm, the shooting hand and possibly clothing of the person shooting are located in cases of close range gunshots. Backspatter on these targets will be reported in a separate publication. The dynamics and three-dimensional quality of backspatter render the reconstruction of trajectories of individual droplets difficult. However, the overall picture of the backspatter stains including the distribution, the travelling distance and the morphology of macro- and microstains can provide valuable information for a reconstruction of events.

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