Forensic Science International 258 (2016) 11–18

Contents lists available at ScienceDirect

Forensic Science International

journal homepage: www.elsevier.com/locate/forsciint

How far does it get?—The effect of shooting distance and type of firearm on the simultaneous analysis of DNA and RNA from backspatter recovered from inside and outside surfaces of firearms

Melanie Grabmüller [a], Philipp Cachée [b], Burkhard Madea [a], Cornelius Courts [a,*]

[a] Institute of Legal Medicine, University of Bonn, Stiftsplatz 12, 53111 Bonn, Germany
[b] Firearms and Ballistic Expert Witness P. Cachée, Birkenweg 6, 14554 Neuseddin, Germany

ARTICLE INFO

Article history:
Received 22 June 2015
Received in revised form 24 September 2015
Accepted 29 October 2015
Available online 10 November 2015

Keywords:
Shooting distance
Backspatter
Molecular ballistics
Forensic DNA analysis
Forensic miRNA analysis

ABSTRACT

When a firearm projectile hits a biological target a spray of biological material (e.g. blood and tissue) is ejected from the entrance wound and propelled back into the direction of the firearm. This phenomenon has been termed 'backspatter' and if backspattered biological material reaches the firearm on its backward trajectory it may persist on and be recovered from the firearm's inside surfaces. Molecular genetic analysis of backspatter generated by contact shots and shots from very short distances has already been demonstrated to critically contribute to victim identification and the reconstruction of firearm-related crimes.

It is not known, however, up to what shooting distance can backspatter be found on firearms' inside surfaces and what influence the weapon's type and caliber has on backspatter attributes (e.g. reach, amount and distribution).

Therefore, the present pilot study investigated the effect of serval combinations of shooting distances and types of firearms and ammunitions on the analyzability of co-extracted DNA and micro-RNA in samples of backspatter collected from interior and exterior surfaces of the firearms after experimental shootings employing standardized ballistic models.

We demonstrate the limiting effect of shooting distance and the type of firearm on the yield of nucleic acids recovered from backspatter and the success rates of forensic DNA profiling and RNA based body-fluid and organ tissue identification in experimental shootings.

1. Introduction

Investigations at crime scenes after criminal acts involving gunshot injuries occurred often encompass the analysis of traces of blood and so-called 'backspatter'. Backspatter is produced by contact shots or shots from short distances at biological targets: A spray of biological material (e.g. blood and tissue fragments) is ejected from the entrance wound into the direction of the firearm. Traces of backspatter may be found on inside surfaces of the firearm (e.g. the barrel inside), on the shooter (e.g. on his/her hands, even his/her back and the shooter's surroundings, where it can persist and be recovered from for forensic analysis. Such traces may be a valuable source of biological material in forensic crime scene investigation and in reconstructing the course of events. The interpretation and analysis of backspatter has already demonstrated its potential for DNA based victim identification in a real case of triple homicide [1] and for hit zone implication via RNA mediated trace contextualization [2].

Another very important aspect of the evidence based reconstruction and legal appraisal of firearm related crimes is the distance from which a shot has been fired. Shooting distances are generally divided into four categories: (1) a 'contact shot' is stated when the firearm's muzzle is held directly against a target. In 'near contact shots' (2) the muzzle is only a few centimeters away from the target. An 'intermediate shot' (3) is stated when the weapon is fired at a distance that preclude signs of (1) and (2) but close enough that backspatter and/or other traces e.g. gunshot residues (GSR) may still reach the shooter and his/her immediate surroundings. Lastly, a 'distant shot' (4) is fired from so far a distance, that typical firearm related traces are not observed [3].

The estimation of the shooting distance is based inter alia on the examination and interpretation of traces at the crime scene that are related to the shooting event. Apart from shooting distance there are several other variables that may influence observable backspatter patterns, such as shot angle, caliber, obstacles in the

* Corresponding author. Tel.: +49 228 73 8355; fax: +49 228 73 8339.
E-mail address: cornelius.courts@uni-bonn.de (C. Courts).

http://dx.doi.org/10.1016/j.forsciint.2015.10.030
0379-0738/

Fig. 1. Overview of used firearms and ammunition for ballistic experiments. (A) a Smith & Wesson revolver caliber 0.38 Special (B) a FÉGARMY Arms Factory semi-automatic pistol caliber 7.65 mm Browning (C) an Astra semi-automatic pistol caliber 9 × 19 mm (D) a semi-jacket soft point bullet (158 gr) fired with revolver caliber 0.38 Special (E) a full metal jacket bullet (124 gr) fired with the two semi-automatic pistols.

projectile trajectory (e.g. windows, clothing), bullet and weapon type, and the target hit zone.

Judging from a thorough literature survey and to the best of our knowledge, previous studies on backspatter [4–6] have not included a systematic investigation of the effect of shooting distance on the molecular biological analysis of traces of backspatter recovered from inside surfaces of firearms and it is currently assumed, that backspatter is recoverable only after close range or contact shots.

Therefore, in this pilot study our aim was to systematically investigate whether backspatter containing forensically analyzable DNA and RNA can be recovered from inside surfaces of firearms after experimental shootings with different distances using different types of weapons and ammunition.

2. Material and methods

2.1. Samples from autopsy cases and ethics

We collected samples of femoral vein blood and brain tissue during three medico legal autopsies (one female, two males) at the Institute of Legal Medicine in Bonn. The samples were used to dope ballistic models as described below. For comparison, reference DNA profiles from pristine autopsy samples were generated as described below.

The study protocol was reviewed and approved by the ethics committee of the Hospital of the University of Bonn.

2.2. Firearms and ballistic models

Firearms and ammunition used for the experimental shootings are shown in Fig. 1 and listed in Table 1. Ballistic models were constructed as a slightly modified version of the ballistic model described elsewhere [7]. Briefly, 750 ml of 10% ballistic gelatine type 'Ballistic III' (Gelita, Ebersbach, Germany) were prepared following Fackler's instructions [8], filled into 1.5 l polyethylene bottles, and stored at 4 °C for 36 h. Subsequently, small 5 × 5 cm plastic foil bags filled with a mixture of 3 ml blood and 300 mg of ground brain tissue of the same source was sealed and attached to each bottle. Finally, the bag was fixed and covered with a 2–3 mm transparent silicon layer (Sista, Henkel AG & Co. KGaA, Düsseldorf, Germany) and stored at 4 °C for 16 h until use (Supplementary Fig. 1).

Table 1
Weapon types, ammunition and sampling locations per firearm.

Weapon	Manufacturer	Caliber	Ammunition	Bullet weight (gr)	Manufacturer	Sampling locations	Orientation
R	Smith & Wesson (USA)	0.38 Special	SJSP	158.0	Fiocchi Munizioni S.p.A (Italy)	All empty chambers	Exterior
						Cylinder	Exterior
						Anterior barrel half	Interior
						Posterior barrel half	Interior
						Muzzle	Exterior
						Trigger guard	Exterior
P	Astra (Spain)	9 × 19 mm	FMJ	124.0	Sellier & Bellot (Czech Republic)	Slide, inner surface	Exterior
						External barrel	Exterior
						Anterior barrel half	Interior
P	FEG (Hungary)	7.65 mm Browning	FMJ	124.0	Sellier & Bellot (Czech Republic)	Posterior barrel half	Interior
						Muzzle	Exterior
						Trigger guard	Exterior

R: revolver; P: pistol; FEG: FÉGARMY Arms Factory; SJSP: semi-jacket soft point; FMJ: full metal jacket; gr: grain (1 gr = 0.065 g).