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ORIGINAL ARTICLE

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Airbag contact in traffic accidents: DNA detection to determine the driver identity

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Abstract A total of 34 deployed driver and passenger airbags from altogether 20 vehicles after frontal collisions were investigated. In 80% of the airbags possible biological traces could be located with an alternative light source (ALS, Polilight) at a wavelength of 450–470 nm. These traces were swabbed, a part of them additionally cut and subjected to DNA analysis, which led to comparable SGMplus profiles in about 60%. In the 20% of the airbags on which no possible biological traces could be located, the whole surfaces were swabbed. In these cases subsequent DNA profiling mostly led to non-interpretable results. For the evaluation and interpretation of the data, buccal swab samples provided by drivers and co-drivers were analysed. The results and conclusions from DNA analyses and the declarations from the involved passengers were always concordant. Thus, molecular biological analysis of deployed airbags can help to determine the occupants positions within a vehicle (driver or passenger status) at the time of impact.

Keywords Airbag · Driver · UV fluorescence · DNA · Forensic

Introduction

Airbags have become an integral part of modern motor vehicle technology. Although their life-saving benefit is beyond question, there is a well known potential of also being a source of injury [1] or even fatality [2, 3, 4] by themselves. Furthermore, airbags can play a role in accident reconstructions when the question who was driving the vehicle when the accident occurred, arises. For determining the occupants' positions within a vehicle, a tight cooperation between motor vehicle technicians, crime scene officers and medical experts is necessary; investigation of the articles of clothing, fibres examinations, and medical inspections or autopsies are the tools involved.

In our study we intended to determine the driver and co-driver positions via DNA analyses from deployed airbags. All accidents that were investigated were frontal collisions. This is a pre-condition for the (driver and co-driver) deployment of the airbag, which takes place at a change in velocity or equivalent energy speed (EES) of about 25 km/h, depending on the technical specifications given by the manufacturers. The force behind this EES delivers the power necessary to generate and deposit DNA samples on the airbag in the form of skin abrasions, nasal mucus or saliva, in some cases also blood, by contact with the occupant. In the on-hand study blood traces were ignored , because if the parties involved in a car accident are injured, such blood traces can be on various places in the car, and it cannot always be assumed that blood spots on an airbag are from the person who was sitting behind this airbag.

We turned our attention to evidence in terms of skin abrasion and cell transfer on deployed airbags – invisible to the naked eye – and the proof of such traces. Furthermore, we wanted to determine the significance of such evidence, to see if the results are in concordance with the declarations from the involved passengers and check if material from other persons than the occupants can be found on the airbags.

Material and methods

Collection and preparation of samples

A total of 34 airbags was investigated in our study in cooperation with the Department of Crime, Gendarmerie Tyrol, Austria. With the informed consent of all parties, a scientific assistant carefully removed the airbags. Before demounting an airbag the upper rear side was marked as an orientation guide for subsequent examinations; aseptic gloves and sterile scalpels were used for handling in general.

In our casework unit the airbags were inspected macroscopically, measured, and characteristics were noted. Combur test strips (Roche Diagnostics GmbH, Germany) were used for the detection

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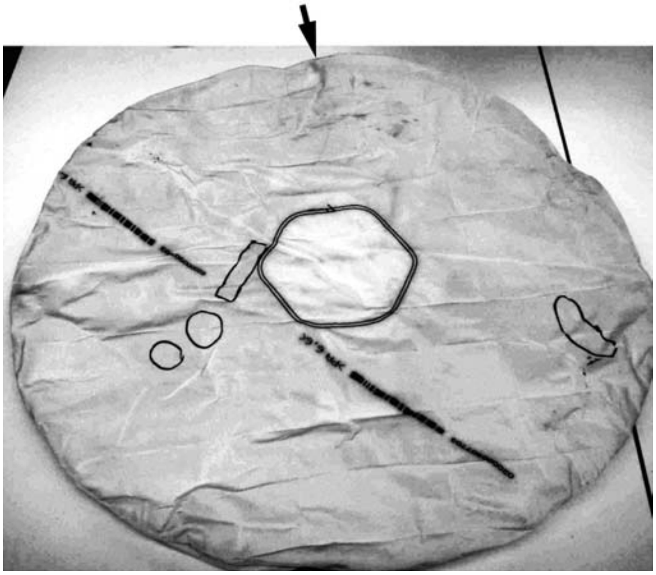

Fig. 1 Demounted driver airbag. Note the marked areas, which are fluorescent traces localised by ALS. The *arrow* marks the upper rear side for orientation

of blood. An alternative light source (ALS; Polilight, Rofin, Australia) at a wavelength of 450–470 nm as recommended in the instruction manual, was utilised for the search for possible biological traces. Such (fluorescent) areas were marked (see Fig. 1); microscopic examinations of some of these areas confirmed evidence in terms of skin abrasion and cell transfer, invisible to the naked eye.

The fluorescent traces were selectively swabbed using moistened sterile cottonwool sticks. To compare different case-work techniques, in 10 cases parts of these areas were additionally cut out.

If no fluorescence was detectable with the alternative light source, the whole surface of the airbags was swabbed using moistened sterile cottonwool sticks (see Table 1).

In all cases in which we could achieve results from DNA analyses, we asked the involved parties (driver/co-driver) to provide buccal swab samples. Altogether we could obtain 10 buccal swab samples (MHA 1–10, see Table 2) from the occupants of 8 vehicles.

DNA extraction/STR amplification and typing

DNA was extracted using the phenol/chloroform method [5]. Amplification was performed using the AmpF*STR SGM plus systems kit (Applied Biosystems, Foster City, CA) according to the manufacturer's recommendations. All PCR reactions were carried out in a Perkin Elmer 9600 thermal cycler, amplification products were separated on a CE310 Genetic Analyser (Applied Biosystems)

Table 1 Examination and characterisation of the airbags as well as subsequent procedures

V	Airbag	Size (cm)	Form	Characteristics	Polilight	Procedure
1	1F	69x60	Tethered		+	Partial swab
	2B	72x75	Tethered		+	Partial swab
2	3F	56	Untethered			Total swab
	4B	73x60	Untethered		+	Partial swab
3	5F	62	Tethered		+	Partial swab, cut-out
4	6F	62	Tethered	Soiled	+	Partial swab
5	7F	62x50	Untethered	Soiled		Total swab
6	8F	62	Tethered	Lipstick	+	Partial swab, cut-out
	9B	80x60	Tethered		+	Partial swab, cut-out
7	10F	65x55	Tethered		+	Partial swab
	11B	70x85	Untethered			Total swab
8	12F	60	Tethered		+	Partial swab
	13B	70x55	Tethered		+	Partial swab
9	14F	65	Untethered			Total swab
	15B	35x40	Tethered	C +	+	Partial swab
10	16F	60	Tethered		+	Partial swab
	17B	65x55	Tethered		+	Partial swab, cut-out
11	18F	60	Untethered	C +	+	Partial swab
	19B		Tethered	C +	+	Partial swab, cut-out
12	20F	70	Tethered		+	Partial swab, cut-out
13	21F	60	Untethered		+	Partial swab
	22B	72x64x45	Tethered		+	Partial swab
14	23F	66	Untethered			Total swab
	24B	70x60	Tethered		+	Partial swab
15	25F	55	Untethered		+	Partial swab
	26B	55x70	Untethered	Soiled, C +	+	Partial swab, cut-out
16	27F	65	Tethered	Soiled		Total swab
	28B	70x60	Tethered		+	Partial swab
17	29F	65	Tethered	Soiled	+	Partial swab, cut-out
18	30F	65	Tethered	Soiled, C +		Total swab
	31B	72x60	Tethered		+	Partial swab, cut-out
19	32F	55	Untethered	Soiled, C +	+	Partial swab
20	33F	60	Tethered	C +	+	partial swab, cut-out
	34B	65	Untethered		+	Partial swab

V Vehicle.
F Driver airbag.
B Passenger airbag.
C + Combur test strip as screening for blood (haemoglobin) with positive result.
Polilight Alternative light source (ALS) as screening for fluorescent traces with positive result.

Table 2 Data interpretation by means of buccal swab samples

V	Airbag	MHA	Procedure	Results/Interpretation	
6	8F	+	Partial swab	No result	
			Cut-out	Female profile	MHA 8F
	9B	+	Partial swab	Mixed profile	MHA 9B/contamination
			Cut-out	Female profile	MHA 9B
7	10F	+	Partial swab	Female profile	MHA 10F
	11B		Total swab	Mixed profile	MHA 10F/contamination
8	12F	+	Partial swab	Male profile	MHA 12F
	13B	+	Partial swab	Female profile	MHA 13B
10	16F	+	Partial swab	Female profile	MHA 16F
	17B		Partial swab	Mixed profile	Contamination
			Cut-out	Female profile	
13	21F	+	Partial swab	Male profile	MHA 21F
	22B		Partial swab	No result	
16	27F		Total swab	Non-interpretable result	
	28B	+	Partial swab	Female profile	MHA 28B
17	29F	+	Partial swab	Male profile	MHA 29F
			Cut-out	Male profile	Contamination
20	33F	+	Partial swab	Male profile	MHA 33F
			Cut-out	No result	
	34B		Partial swab	Non-interpretable result	

V Vehicle.
F Driver.
B Passenger.
MHA Buccal swab sample.

using default conditions (24 min at 15 kV, POP 4). Extraction blanks and PCR negative and positive controls were carried out through the entire process. Data were analysed using GeneScan Analysis (versions 2.1 and 3.7) and Genotyper (version 3.6).

Results

The use of an alternative light source (ALS, Polilight) revealed fluorescent areas on 27 airbags, which means a positive rate of nearly 80% (see Table 1). From 27 partial swabs done from fluorescent traces, we obtained full DNA profiles 14 times, mixed profiles 4 times and no interpretable results 9 times. From 10 cut-outs also done from fluorescent traces, we achieved full profiles 7 times and no interpretable results 3 times. Overall, regarding the success rate, there was no difference between the typing results achieved from partial swabs or from cut-outs.

Passengers of 8 vehicles provided buccal swab samples, so the results from the corresponding airbags could be further interpreted in these cases (see Table 2). The declarations from the involved passengers concerning their driver or co-driver status, affirmed by their STR profiles, were always in concordance with the achieved profiles from the accordant airbags. In the case of vehicle 7, the female profile of the driver was also part of a mixed profile, which was achieved after a total swab of the co-drivers airbag. The other (male) part of this mixed profile could be explained by the profile of the scientific assistant from our institute who had demounted the airbag (see Fig. 2). In this case no co-driver was in the vehicle at time of accident, according to the statement of the driver. In two other cases (vehicles 6 and 10) contamination was noted due to contact from the person demounting the airbag. In the case of vehicle 17 we did 2 analyses from different fluorescent areas from the driver airbag: a partial swab yielded a DNA profile identical with the profile from the driver, and a cut-out resulted in a different male profile. This profile matched neither the occupant nor the assistant nor any of the laboratory personnel, and was therefore not allocatable for us; a further contamination from the manufacturers, mechan-

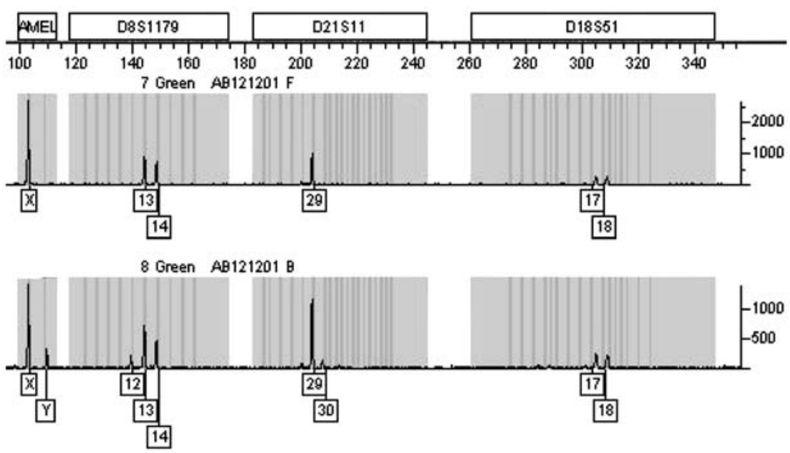

Fig. 2 Vehicle 7. Partial swab from the driver airbag, total swab from the co-driver airbag. SGM plus (ABI) electropherograms, JOE-labelled profiles (*green*) only. *First line* female profile from driver airbag, *second line* mixed profile from co-driver airbag

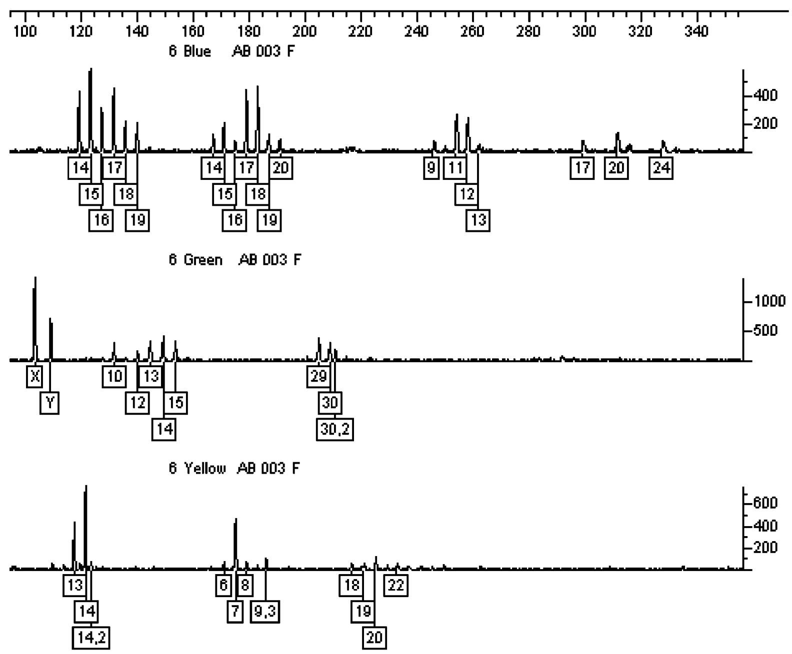

Fig. 3 Vehicle 2. Total swab from the driver airbag. SGM plus (ABI) electropherogram

ics, police officers or even ambulance men has to be considered here.

From the other 7 airbags, on which no possible biological traces could be located by the ALS, total swabs were prepared. In one case we obtained a mixed profile being interpretable (see Fig. 2, mixed profile from co-driver airbag). In all the other cases we achieved no results at all or mixed profiles which were not interpretable; such an example is shown in Fig. 3.

Discussion

In cases of road accidents with more than one vehicle passenger being involved, the identity of the driver is an outstanding question for insurance and legal purposes. It is often the task of the forensic pathologist to find answers to this question by physical examinations or autopsies of the occupants. Without a tight cooperation with motor vehicle experts a definite statement is not possible in many cases.

It is known that in most accidents involving a head-on crash, a more or less close contact between a deployed airbag and the person sitting behind it occurs, although not always causing obvious injuries. A transfer of biological material can then be expected, for example by slight abrasions of the skin. It was the aim of the present study to investigate such traces, and if a DNA profile could be obtained, to see if the results are consistent with the statements of the interrogated accident vehicle occupants. In none of the cases investigated was this statement relevant under legal or financial aspects.

UV fluorescence has been known for detection of biological traces for a long time [6, 7, 8]. In the present study the use of an alternative light source (ALS, Polilight) has turned out to be a reasonable screening method for the examination of the airbags. On nearly 80% of all deployed airbags fluorescent areas could be detected and based on that, swabs and cut-outs of these areas were prepared. In cases of cut-outs we only had either full DNA profiles or no results at all, due to the fact that only a small piece of material was cut out and subsequent profiled, whereas in cases of partial swabs, where a bigger area from the airbag was investigated, mixed profiles were also obtained. The overall success rate of profiling these samples was about 60%. Altogether there was no difference between utilisable results achieved from partial swabs or from cut-outs.

On the contrary, for the other 20% of the airbags on which no fluorescent traces could be located by use of ALS, preparation and profiling of swabs of the whole surface of the airbags was counterproductive: except for one case no further interpretable results were obtained.

The presented investigation strategy is appropriate to locate biological evidence on airbags invisible to the naked eye, in order to achieve individualising DNA profiles. Careful detection of possible biological traces increases the chance of a successful STR analysis in the airbag samples involved. Great importance also has to be attached to prevention of contamination. Although reasonable precautions were taken while demounting the deployed airbags, contamination from our scientific assistant occurred in a few cases. The conclusion is that for taking evidence in car accidents the same precautions have to be applied as in crime scene investigations [9]. Theoretically also a third party contamination, e.g. from the manufacturers, mechanics, police officers or ambulance personnel is possible [10]. As in practical applications known DNA profiles are available for comparison, a possible contamination should easily be detectable.

Altogether, we suggest that molecular biological analysis will take root as another tool in the forensic investigation of driver attribution, combined with the investigation of the vehicles and accident reconstruction on the one hand and medical inspections or autopsies of the occupants on the other hand.

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References

1. Sato Y, Ohshima T, Kondo T (2002) Air bag injuries – a literature review in consideration of demands in forensic autopsies. Forensic Sci Int 128:162–167
2. Cooper JT, Balding LE, Jordan FB (1998) Airbag mediated death of a two-year-old child wearing a shoulder/lap belt. J Forensic Sci 43:1077–1081
3. Jumbelic MI (1995) Fatal injuries in a minor traffic collision. J Forensic Sci 40:492–494
4. Mbamalu D, Banerjee A, Shankar A, Grant D (2000) Air bag associated fatal intra-abdominal injury. Injury 31:121–122
5. Parson W, Pegoraro K, Niederstatter H, Foger M, Steinlechner M (2000) Species identification by means of the cytochrome b gene. Int J Legal Med 114:23–28
6. Lynnerup N, Hjalgrim H, Eriksen B (1995) Routine use of ultraviolet light in medicolegal examinations to evaluate stains and skin trauma. Med Sci Law 35:165–168
7. Springer E, Almog J, Frank A, Ziv Z, Bergman P, Qiang WG (1994) Detection of dry body fluids by inherent short wavelength UV luminescence: preliminary results. Forensic Sci Int 66:89–94
8. Stoilovic M (1991) Detection of semen and blood stains using polilight as a light source. Forensic Sci Int 51:289–296
9. Rutty GN, Hopwood A, Tucker V (2003) The effectiveness of protective clothing in the reduction of potential DNA contamination of the scene of crime. Int J Legal Med 117:170–174
10. Rutty GN (2002) An investigation into the transference and survivability of human DNA following simulated manual strangulation with consideration of the problem of third party contamination. Int J Legal Med 116:170–173