Forensic Science International 249 (2015) 225–232

Contents lists available at ScienceDirect

Forensic Science International

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

The application of imaging technologies in the detection of trace evidence in forensic medical investigation☆

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ARTICLE INFO

Article history:
Received 3 August 2014
Received in revised form 25 January 2015
Accepted 2 February 2015
Available online 9 February 2015

Keywords:
Trace evidence
Imaging technology
Alternate light source
Evidence detection
Forensic medical investigation

ABSTRACT

In a country notorious for violent crime, it seems that South African medico-legal laboratories make minimal application of technology in the death investigation process and little attention is given to trace evidence. Non-destructive, non-invasive, portable and cost-effective tools are required. This study was conducted at the Pretoria Medico-Legal Laboratory. The surface area of the bodies and clothing of victims of fatal interpersonal violence were examined using a torch, magnifying lamp, portable digital microscope and alternate light source to gauge their potential for trace evidence detection. Most studies apply these and similar tools to inert surfaces, with few focusing on their application to human skin. There was a statistically significant difference in the detection of many of the evidence types between the naked-eye observation of the pathologists and the technologies. The different imaging technologies were compared as to their cost, evidence detection ability and ease of use. The most common evidence types discovered on the bodies and clothing of victims of fatal interpersonal violence, as well as the propensity of each tool to detect these, was evaluated in order to devise the best option for incorporation into the Pretoria Medico-Legal Laboratory routine. The digital microscope performed best overall followed by the magnifying lamp, torch and the Polilight®. This study aimed to justify the investment of more time, effort and funding into trace evidence recovery in the South African mortuary environment.

1. Introduction

Locard's Exchange Principle: "Every contact leaves a trace" encapsulates the fact that evidence found at a crime scene can create links between the perpetrator and the victim [1]. There is virtually no limit to the traces that could be found on a victim's body, albeit each with varying degrees of uniqueness and subsequent usefulness to the investigation. This evidence can prove that a suspect came in contact with the victim around the time of the crime, and can subsequently serve to incriminate or exonerate the individual [2]. In fatal cases, the body should be treated with the same care, diligence and vigilance as the physical crime scene; and trace evidence should be meticulously sought for in the same manner. In homicidal cases and pedestrian vehicle accidents (PVA) there is potential contact between the victim and the offender and/or weapon. Homicide accounts for over 500,000 deaths per year worldwide and 270,000 pedestrians lose their lives on the roads each year [3,4].

Burton [5] considers the initial external examination of victims' bodies to be neglected, poorly documented and not routinely thoroughly inspected for trace evidence in mortuaries [5]. The medico-legal investigation of death is in need of ancillary testing technologies which deliver reproducible, reliable results and are non-destructive [2]. Factors such as cost, ease of use and portability need to be considered when choosing imaging technologies for trace evidence recovery. Pretoria is the capital city of South Africa with an estimated population of 2,141,717 (2007) [6]. This study was conducted at the Pretoria Medico-Legal Laboratory (PMLL), which admits the majority of cases from Pretoria. A torch, magnifying lamp, portable digital microscope and alternate light source were tested to gauge their potential for trace evidence detection on the bodies of victims of fatal interpersonal violence.

2. Material and methods

2.1. Setting

This was a prospective study conducted over a 6-month period at the PMLL. The study proposal was approved by the University of

☆ This work has not been previously published, except in the form of an academic dissertation and was presented at the 2nd National Forensic Services Conference in South Africa.

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http://dx.doi.org/10.1016/j.forsciint.2015.02.005
0379-0738/

Pretoria's Faculty of Health Sciences' Research Ethics Committee, the MSc Committee and the relevant authorities at the PMLL.

2.2. Case selection

Any case where it was considered by the researcher and/or attending pathologist that there may have been some sort of violent interaction resulting in a possible transfer of physical evidence was included in the study. This included victims of homicidal blunt-force and sharp-force trauma, manual and/or ligature strangulation and a number of pedestrian–vehicle accidents (PVA).

Cases where perpetrator–victim contact was expected to be minimal (such as gunshot-wounds and vehicle occupants in road-traffic accidents), as well as decedents who were hospitalized, were excluded.

2.3. Technologies

Four technologies were tested in this study. The first was a torch, the LED Lenser® M7 (R500.00–R800.00). The torch makes use of "High End Power LEDs" and is 137 mm long and weighs 193 g. It produces 220 Lumens and operates on 4 AAA batteries. It has a burning life of 11 h and a beam range of 255 m.

A magnifying lamp was used secondly (model number MLPF8066-1BHC) (R400.00–R1000.00). It has a 125 mm diameter, 8,3 dioptre glass lens allowing for 3× magnification. The arm length is 410 mm and the entire unit clamps onto a desktop. It operates from a 220 V mains supply and has a fluorescent ring light surrounding the lens.

Thirdly, the Veho VMS-004 USB Microscope (digital microscope) was used (R300.00–R2000.00). It has dimensions of 125 mm × 33 m, with a 1.3 Mega Pixel image sensor and still- and video-capture capabilities. It has a manual focus range from 10 mm to 500 mm and a magnification ratio of 20× and 400×. Illumination is provided by an 8 LED light source which can be adjusted by a control wheel. The microscope is powered via the USB port in a computer. Microcapture software is included which allows approximate measurements to be calculated on the images.

A forensic light source (Alternative Light Source) was also procured on indefinite loan from the South African Police Service (SAPS). The unit used was a Polilight® PL500 from Rofin Australia (Pty) LTD (R38,000.00–R450,000.00). It is a 500 W high-intensity Xenon light source with dimensions of 33 × 15 × 37 cm and weighing 9.9 kg. It uses a 2 m long flexible liquid light guide and 12 selectable and tuneable filters to generate light of varying wavelengths. It uses a standard power supply ranging from 90 to 260 V and 50 to 60 Hz. Four pairs of coloured goggles accompany the unit for the user's protection. Coloured camera filters are also provided to allow documentation of findings.

2.4. Methodology

The body of each victim included in the study was viewed by the attending pathologist in the medico-legal mortuary and then subsequently undressed by the attending prosector. The bodies were not washed or cleaned in any way and the body was then moved to an adjacent room for examination purposes.

The clothing and body were examined with the technologies in the following order: first using the torch, then the magnifying light, the digital microscope and lastly the Polilight®. The rationale for the order of use of the technologies was intended to go from perceived weakest – and therefore least likely to detect evidence – to strongest, to try and eliminate the bias of seeking out already-found evidence. The digital microscope was used at 20× magnification and was connected to an HP ProBook 4515s laptop using Windows® 7 Home Basic. The Polilight® was set at 450 nm at full power (P8) in conjunction with orange filter goggles.

The clothing was laid out on a workbench in the room for inspection by the forensic scientist. One scientist did all the examinations in order to eliminate inter-observer discrepancies. Just the outer layers of clothing – where contact was expected to occur – were examined. The examination of the clothing took an average of 30 min.

The bodies were subsequently examined using the technologies in the same order as for the clothing. The anterior aspect of the body was examined first (with all 4 technologies) where after the body was turned over in order to examine the posterior aspect of the body. It took approximately 60 min to examine the entire surface area of the body with all 4 technologies. Evidence that was discovered was noted. Evidence was divided into the following categories: fibres/hairs, fluid (this did not include what appeared to be condensation from refrigeration), geological samples (gravel, sand, dirt, etc.), botanical samples (grass, leaves, seeds, etc.), paint, glass, impression marks (areas of constriction or pressure that may highlight areas worth investigating for touch DNA, for example in cases where a victim was throttled), entomological samples (insects, maggots, etc.) fingerprints, tattoos, plastic and paper. Any other traces, such as smears, flecks, powders, mould, soot/ash etc., were grouped into the category of 'other evidence'. The traces were grouped in this manner in order to simplify the results and because they could not be definitely and uniquely identified without further testing. The collection of samples and further confirmatory testing was beyond the scope of the study; therefore evidence found could only be given assumptive descriptions and may not have been their true identities. Certain crimes or circumstances of death may show correlation with certain evidence types, for example, body fluids and rape-homicides. This categorization allows one to identify particular technologies which would be of the most use for a particular case type or external cause of death.

The attending pathologist was informed of the evidence discovered through the examinations and it was left to their discretion whether or not to collect samples. Interesting findings or representative examples were photographed. Evidence noted in the subsequent pathologists' reports was taken as naked-eye observations for comparative purposes.

The different imaging technologies were compared as to their cost, evidence detection ability and ease of use.

2.5. Statistical analysis

Assistance with statistical analysis was sought from the Statistics Department at the University of Pretoria. The IBM SPSS Statistics Version 21® program was used for the statistical analysis. The approach was a pairwise comparison of technologies for each type of evidence.

In order to compare the efficacy of two devices to find evidence, the McNemar Test was used because the same bodies were searched using the different technologies, making the observations paired observations. In comparing Technology A to Technology B, the number of times evidence was found by means of Technology A and not by B is compared to the number of times evidence was found by means of Technology B but not by means of Technology A. The evidence found by both or by neither plays no role in this comparison. McNemar Tests could not be performed in the cases where one or both technologies being compared failed to find anything in that evidence category. A p-value of less than 0.05 was taken as indication of a significant difference.