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Reactions of latent prints exposed to blood

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ABSTRACT

We explored whether an undeveloped latent print (fingermark) exposed to blood and later developed by enhancement with blood reagents such as amido black (AB) or leucocrystal violet (LCV) could appear as a genuine blood mark. We examined three different experimental conditions. In Experiment I, fingermark residue only was tested, as a control to confirm that fingermark residue alone does not react with the blood reagents AB and LCV. Experiment II investigated whether latent fingermarks exposed to blood dilutions could be treated with AB or LCV and subsequently appear as a genuine blood mark enhanced with AB or LCV. Experiment III tested whether latent fingermarks exposed to whole blood could be processed with AB or LCV and subsequently appear as a genuine blood mark enhanced with AB or LCV.

The present study found that indeed, fingermark residue alone does not react with the blood reagents AB and LCV. In Experiment II, an interaction occurred between the fingermark residue and the diluted blood that caused the ridges to appear a red color. In the present study, this interaction is called a faux blood mark. While the faux blood mark phenomenon occurred most often following exposure to diluted blood, it did not occur consistently, and a predictable pattern could not be established. However, the reaction occurred more frequently following extended fingermark residue drying times. Faux blood marks are distinguishable from genuine blood marks prior to enhancement with blood reagents. Following treatment with blood reagents, it became increasingly difficult to determine whether the enhanced mark was a genuine blood print or a latent fingermark exposed to diluted blood. Latent fingermarks exposed to whole blood often resulted in a void prior to enhancement, but following treatment with blood reagents, were difficult to distinguish from a genuine blood mark enhanced with blood reagents.

1. Introduction

The question of whether a latent fingermark can be processed with blood reagents and subsequently be mistaken for a bloody fingermark has been asked too frequently in recent years to be ignored.[1] In a case from New York in 2005, a young woman, Catherine Woods, was violently killed in her apartment. A bloody fingermark, from a section of drywall in the apartment, was enhanced with the dye stain amido black. This fingermark was subsequently matched to her boyfriend, Paul Cortez, who was charged with her murder. As recounted by LaRosa and Moriarty [1], this fingermark was a crucial piece of evidence that was fiercely debated at the trial. Confusion over terminology made it unclear whether the developed mark was a "latent print" (invisible) or a "patent" (visible) blood print. The technician who processed the mark testified that he did not see ridge detail until he had applied the dye stain. The defense attorney used this statement to imply the mark may not have been deposited in the victim's blood, as it was not visible prior to enhancement. The implication here is that Cortez deposited a latent fingermark at a previous point in time under legitimate circumstances. However, when the latent fingermark was exposed to incidental blood during the violent killing of Woods, the blood reagent amido black enhanced the fingermark that was *covered* in the blood, ultimately making it appear that the mark was deposited in blood and thus a genuine bloody fingermark.

As mentioned by Champod et al. it is understood that latent residue from a fingermark will not be visualized by blood reagents such as amido black [2]. Both Creighton [3] and Huss et al. [4] explored the potential of a latent fingermark to assume the appearance of a bloody fingermark after post-deposition exposure to blood. Huss et al. [4] determined that sebaceous marks on a

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[1] The authors have received several phone calls from criminal defense attorneys in capital cases related to this issue. In one case, an apparent bloody toe print was found on a bathroom floor, surrounded by bloody bath water. Hence, we added trials to explore the effects of blood diluted with water.

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horizontal surface exposed to a smear of blood could assume the appearance of a bloody tonal reversal.[2] They explained this phenomenon with the proposition that blood is repelled by the oily sebaceous residue on the ridges and is collected in the furrows.

The possibility that an interaction with blood reagents may occur after the fingermark residue has been exposed to blood is an unanswered question. This is what Paul Cortez's defense team was suggesting might have happened in 2005. As voiced by defense attorney Dawn Florio, "Is it possible that the print enhanced with the amido black was not a bloody print?" [1]. To date, there is nothing reported in the literature that *systematically* explores this issue. The correlation between evidence of this nature and violent crimes against persons implores an investigation of this topic in order to assuage doubt in relevant cases.

2. Terminology

Traditionally, the word fingermark represents a deposit by a finger, which may or may not contain comparable ridge detail, and may or may not have been visually enhanced and processed with chemical or physical treatments. In this article, for the purposes of specificity, the authors mean to make clear that a latent fingermark (as used by Champod et al. [2]) represents an invisible, untreated, non-enhanced mark made only of eccrine/sebaceous residues. In addition, the following terms will be used to define the different types of marks observed in this study in order to properly distinguish them from one another and to make the differences clear to the reader. A patent blood mark or bloody fingermark, is a *visible* mark deposited with blood on the ridges. A latent blood mark is an *invisible* mark deposited with an imperceptible amount of blood on the ridges. Both patent and latent blood marks can also be described as genuine blood marks, as there is actually blood on the ridges upon deposition. Two novel terms will also be introduced in this article. A faux blood mark is a *visible* mark seen following the interaction of a latent fingermark exposed to blood. Finally, a negative blood mark is an *invisible* mark seen when a latent fingermark is exposed to blood but in this case, a clear void or halo forms around the latent fingermark residue. A faux blood mark can be interpreted as the counterfeit to a patent blood mark, and a negative blood mark can be seen as the counterfeit of a latent blood mark.

3. Methods and procedure

3.1. The reagents

Leucocrystal violet (LCV) is a highly specific stain that can react with heme-containing compounds, such as hemoglobin found in red blood cells.[3] The hydrogen peroxide used to make LCV binds to hemoglobin and the crystal violet stains the blood mark a brilliant violet color [6]. See Appendix A for the formula and procedure for application.

Amido black (AB) is a general protein stain that interacts with proteins found in serum and the cell matrix of blood. The anionic ends of the molecule bind to cationic ends of the basic amino acids. Blood marks are stained a blue to black color [5]. See Appendix B for the formula and procedure for application.

3.2. Types of residue

Eccrine glands produce sweat and although they are located all over the body, they are the only glands found on the palms of the hands and the soles of the feet. Sebaceous glands secrete oil (sebum) and are located all over the body (except palms and soles of feet) with the highest concentrations on the forehead, chest and back [2]. For the excess sebaceous residue condition, donors were asked to swipe their forehead or the bridge of their nose to gather extra sebum from the face. For the excess eccrine residue condition, donors were asked to wear a rubber glove for approximately 15 min so as to increase sweat accumulation prior to deposition. In 'natural' residue trials, donors were asked to deposit fingermarks as they were, without prior collection of extra sebum or sweat on the ridges. Donors were not asked to wash hands prior to collecting excess sebum or sweat or before depositing marks in the 'natural' trials.

After deposition, the fingermark residue was allowed to dry on the glass surface for at least 15 min (and in some trials significantly longer drying times were employed, i.e. up to 1 week).

Human blood was used in these experiments. Fresh blood was drawn by a trained phlebotomist. Blood was stored in purple cap (containing anticoagulant) tubes and refrigerated when not being used. Previous studies have noted that anticoagulant does not affect blood drying times at these small volumes, but obviously affects blood clotting times [7,8]. When not used immediately, the blood was usually used within a few days of collecting. Blood that had been refrigerated was gently warmed in a heating block to approximately 37 °C before use.

Testing was divided into three experiments. Experiment I served as a control to show that AB and LCV do not react with latent residue. Experiment II tested the use of blood dilutions from 1:1 to 1:100 (blood:water) to investigate the possibility that a latent fingermark exposed to diluted blood may resemble a bloody fingermark following enhancement with AB or LCV. In Experiment III, the latent fingermarks were exposed to whole blood in order to more closely imitate typical crime scene conditions. For each trial in Experiment I and Experiment II, a clean, glass 9 in. × 13 in. baking dish (clear), was divided into 6 rows using masking tape. Only one type of secretion residue was used per glass dish (i.e. one glass dish = one trial). For each trial, each donor (6 per trial) was asked to deposit between 6 and 8 latent fingermarks using the finger of their choice (usually the thumb, index or middle) in a row across the pan, one donor per row. Hence, each trial typically tested between 36 and 48 marks. Multiple trials were run for each type of residue (e.g. 5 sebaceous trials, 5 eccrine trials and 5 'natural' trials). The masking tape was removed after the latent residue had dried.

3.3. Experiment I: testing on latent fingermark residue

Twenty eight trials were run in Experiment I. All three types of residue conditions were used throughout these trials. Each blood reagent was tested on all three types of residue. Latent residue was allowed to dry for 15 min before application of LCV or AB. Latent fingermarks from over 20 different donors were collected.

3.4. Experiment II: testing on latent fingermarks exposed to blood

The first trials in this experiment were conducted using the three residue conditions described above ('natural', eccrine and sebaceous). Subsequent trials used only sebaceous marks as the other two types of residue conditions produced very faint, if any, reactions. Latent fingermarks were deposited in two clean glass baking dishes. The latent residue was allowed to dry for at least 20–30 min (with the exception of the trials where the latent fingermarks sat out at room temperature for 1 week). A 1:1 blood dilution using 20 ml of tap water and 20 ml of blood was prepared and poured over the latent fingermarks to form a layer on the bottom of the dish. This was allowed to sit in the pan for about 15 min before the excess liquid was drained and removed (no rinsing was performed). After drying for another 20 min, AB was then applied to one pan and LCV to the other. Dilutions of 1:10 and 1:100 (blood:water) were also tested.

3.5. Experiment III: testing with whole blood

In these trials, latent fingermarks consisting primarily of sebaceous residue (due to the success of this condition in Experiment II) were exposed to whole blood. For these trials, glass microscope slides were used as the surface. There were two primary reasons for this: the slides bore less surface area thereby decreasing the amount of blood needed to expose the latent fingermarks, and they are much easier to handle and transport.

A sampling of sebaceous marks from 10 individuals was obtained. Latent fingermarks were deposited on one end of a glass microscope slide and allowed to dry for 30 min. The marks were then individually submersed *vertically* into approximately 40 ml of whole blood to coat the end of the slide bearing the mark. This was done as quickly as possible; the latent fingermark was exposed to blood for approximately 3–5 s. The slide was allowed to dry at room temperature for approximately 10 min. In another set of the trials, blood was dripped or poured directly on the latent fingermark in the *horizontal* position and allowed to dry for 30 min on the latent fingermark (without removing any of the excess blood, which would have occurred naturally due to gravimetric flow in the vertically dipped trials). After examining and recording the extent of interaction between the blood and the latent fingermark residue, the slides were processed with either LCV or AB.

4. Results and discussion

Experiment I was conducted as a control step for the reaction, or rather lack thereof, between latent fingermark residue and the blood reagents. Indeed, no reaction occurred between any of the

[2] A tonal reversal is defined as the ridges and furrows visualized by colors that are the opposite as that expected for the signature of the development medium. For example, when an analyst develops a fingermark with black powder, the expectation is that the ridges will be black and the furrows white. In a tonally reversed mark, the furrows will develop as black and the ridges as white.

[3] It should be noted that peroxidase reacting reagents like LCV could result in false positives with a variety of substances.