Revista Científica del Centro Universitario de la Guardia Civil
Revista Lógos Guardia Civil

Research Article

THE ANALYSIS OF BLOODSTAIN PATTERNS AS A KEY PIECE OF EVIDENCE IN THE RECONSTRUCTION OF A MURDER

English translation with AI assistance (DeepL)

Joaquín Álvaro Vázquez
Higher Diploma in Criminology
Forensic Laboratory of Guardia Civil Headquarters in Badajoz
ORCID: 0009-0006-4324-8817
joaquinalvaro@hotmail.es

Received 28/03/2026
Accepted 02/06/2026
Published 30/06/2026

doi: https://doi.org/10.64217/logosguardiacivil.v4i2.9023

Recommended citation: Álvaro Vázquez, J. (2026). The analysis of bloodstain patterns as a key piece of evidence in the reconstruction of a murder. *Revista Logos Guardia Civil*, 4(2), pp. 39–58. https://doi.org/10.64217/logosguardiacivil.v4i2.9023

Legal Deposit: M-3619-2023
NIPO online: 126-23-019-8
Online ISSN: 2952-394X

doi: https://doi.org/10.64217/logosguardiacivil.v4i2.9023 ORCID: 0009-0006-4324-8817

THE ANALYSIS OF BLOODSTAIN PATTERNS AS A KEY PIECE OF EVIDENCE IN THE RECONSTRUCTION OF A MURDER

Summary: 1. INTRODUCTION. 2. METHODOLOGY. 3. CASE DESCRIPTION. 4. BLOODSTAIN PATTERNS DOCUMENTED AT THE CRIME SCENE. 4.1. Hallway. 4.2. Master bedroom. 4.3. Living room. 5. DISCUSSION. 5.1. Scientific reliability of bloodstain pattern analysis (BPA) and international validation standards. 5.2. BPA in the Spanish legal system. 5.3. Inherent limitations of the analysis. 6. CONCLUSIONS. ETHICAL STATEMENT. CONFLICT OF INTEREST. BIBLIOGRAPHICAL REFERENCES. REGULATIONS.

Abstract: The analysis of bloodstain patterns (BPA) is a fundamental tool for reconstructing the dynamics of violent incidents at the crime scene. This paper presents the analysis and interpretation of bloodstain evidence documented in a murder case that occurred in the town of Zafra (Badajoz) in 2024, as part of a technical-police visual inspection carried out using a unified approach and a manual methodology supported by trigonometry.

Based on the study of the morphology, distribution and correlation of the bloodstains with the forensic findings, the sequence of events most consistent with the physical evidence is reconstructed, identifying the initial scene, the victim's movements and the subsequent phases of the incident. Evidence consistent with tampering with the scene is also analysed, including patterns of selective cleaning and re-entry into the premises.

The case is of particular evidential interest as it took place in a context characterised by the limited conclusiveness of other expert reports and the coexistence of contradictory hypotheses. In this scenario, the BPA played a central role in the joint assessment of the evidence. The scientific reliability of the discipline, its place within the Spanish procedural framework, the implications of expert testimony before the jury court, and the limitations inherent in the analysis are discussed.

Resumen: El análisis de patrones de manchas de sangre (BPA) constituye una herramienta fundamental para la reconstrucción de la dinámica de los hechos violentos en la escena del crimen. El presente trabajo expone el análisis e interpretación de los rastros hemáticos documentados en un caso de asesinato ocurrido en la localidad de Zafra (Badajoz) en 2024, en el marco de una inspección ocular técnico-policial desarrollada bajo criterio unitario y metodología manual con soporte trigonométrico.

A partir del estudio de la morfología, distribución y correlación de los rastros de sangre con los hallazgos médico-legales, se reconstruye la secuencia dinámica más compatible con la evidencia física, identificando el escenario de inicio, los desplazamientos de la víctima y las fases posteriores del evento. Se analizan, asimismo, indicios consistentes con alteración de la escena, incluyendo patrones de limpieza selectiva y reingreso al inmueble.

El caso presenta especial interés probatorio al haberse desarrollado en un contexto caracterizado por la limitada conclusividad de otras pericias y la coexistencia de hipótesis contradictorias. En este escenario, el BPA adquirió un papel central en la valoración conjunta de la prueba. Se discuten la fiabilidad científica de la disciplina, su encaje en el marco procesal español, las implicaciones de la comunicación pericial ante el Tribunal del Jurado y las limitaciones inherentes al análisis.

doi: https://doi.org/10.64217/logosguardiacivil.v4i2.9023 ORCID: 0009-0006-4324-8817

Keywords: bloodstain pattern analysis, BPA, forensic reconstruction, expert evidence, jury trial.

Palabras clave: análisis de manchas de sangre, BPA, reconstrucción forense, prueba pericial, Tribunal del Jurado.

ABBREVIATIONS

BPA: Bloodstain Pattern Analysis

ENFSI: European Network of Forensic Science Institutes

IABPA: International Association of Bloodstain Pattern Analysis

LECrim: Code of Criminal Procedure

NAS: National Academy of Sciences (US National Academy of Sciences)

NIST: National Institute of Standards and Technology

OSAC: Organisation of Scientific Area Committees

PCAST: President's Council of Advisors on Science and Technology

SWGSTAIN: Scientific Working Group on Bloodstain Pattern Analysis

TSJ: High Court of Justice

1. INTRODUCTION

Bloodstain pattern analysis (BPA) has, since the pioneering experiments of Eduard Piotrowski (1895) in the late 19th century and the subsequent contributions of Victor Balthazard (1939) in the field of forensic science, been a discipline aimed at reconstructing the sequence of events through the study of bloodstain evidence. Its purpose is not to identify the perpetrator, but rather to interpret the mechanisms that generate the traces, thereby enabling the inference of relative positions, sequences of actions and dynamics of movement (Bevel & Gardner, 2008; James et al., 2005). Following the work of Paul L. Kirk (1955) on the Sam Sheppard case, BPA gained international prominence as an essential tool for analysing crime scenes.

From a methodological perspective, BPA is based on the correlation between the morphology of the bloodstains, their spatial distribution and the physical conditions under which they are generated. The interpretation of these patterns requires consideration of variables such as the viscosity of the blood, the velocity of projection, the angle of impact and the nature of the contact surfaces. Blood, as a non-Newtonian fluid with complex behaviour, generates patterns upon impact with a surface, the morphology of which is determined by physical quantities that are verifiable and experimentally reproducible (Attinger et al., 2013). Among the phenomena relevant to the chronological interpretation of the evidence is what is known as ‘skeletonisation’: a process whereby a bloodstain, as it dries, develops a darker and denser perimeter than the central area, as a result of the differential drying of the blood’s components. The presence of skeletonised stains acts as a qualitative chronological marker, indicating that these stains were produced sufficiently prior to the inspection for the drying process to have begun to a perceptible extent.

The standardisation of terminology and concepts within the discipline has been driven by international bodies such as the Scientific Working Group on Bloodstain Pattern Analysis (SWGSTAIN), whose recommendations have contributed to the establishment of common interpretative criteria. The scientific credibility of BPA, however, has not been without its critics. The report by the US National Academy of Sciences (NAS, 2009) highlighted the lack of rigorous empirical validation studies and the excessive reliance on individual expert judgement. This assessment, reinforced by the report from the President’s Council of Advisors on Science and Technology (PCAST, 2016), led to the creation of the Organisation of Scientific Area Committees (OSAC) under the auspices of the National Institute of Standards and Technology (NIST), with a mandate to establish empirically grounded standards of forensic practice. Subsequent validation work has helped to define ranges of reliability for certain pattern classifications (Attinger et al., 2013; Taylor et al., 2016), although the debate regarding the margins of uncertainty in the interpretation of certain patterns remains open.

From a procedural perspective, it is important to clarify the conceptual distinction between circumstantial evidence and expert evidence as set out in Spanish law. Circumstantial evidence is observable data—the morphology and characteristics of a blood-like stain, for example—from which, through logical-inductive reasoning, an unknown fact is inferred with varying degrees of probability. It is important to emphasise that the very identification of that piece of data is subject to varying levels of certainty: the visual observation of a blood-like stain constitutes nothing more than a preliminary inference based on morphology and context; presumptive tests reinforce this inference but do not confirm it, as they are susceptible to false positives with other oxidising

doi: https://doi.org/10.64217/logosguardiacivil.v4i2.9023 ORCID: 0009-0006-4324-8817

substances; and analytical confirmation in the laboratory, whilst representing the highest level of accreditation available, does not guarantee absolute certainty either, given that it may produce false negatives depending on the degree of sample degradation. Within the framework of Good Laboratory Practice (GLP), analysis is usually carried out on stains whose nature has been corroborated by presumptive tests, a condition which adds a layer of epistemic conditioning that must be explicitly acknowledged in any reconstructive conclusion. Expert evidence, regulated by Articles 456 to 485 of the Criminal Procedure Act (LECrim), is the formal means through which this inductive reasoning is introduced into the judicial process, subject to cross-examination by the parties and free assessment by the court in accordance with Article 741 of the LECrim. BPA therefore operates at the level of material evidence; it is expert evidence that provides the means by which such evidence acquires procedural relevance. This distinction is not merely terminological: it determines the level of certainty required of the conclusions and the degree of epistemic modulation with which they must be formulated.

At the international level, the practice of BPA frequently relies on specialised computer tools such as ISA Forensic, HemoVision or the Leica Map360 mapping software, which automate trigonometric calculations and enable the three-dimensional visualisation of trajectories. These tools do not alter the underlying mathematical principles, but rather accelerate and automatically document the same procedures that can be carried out manually using trigonometric tables—a method that remains valid and reproducible in operational contexts where such tools are not available.

In Spain, the development of BPA has been more limited than in the leading Anglo-Saxon countries. Although routinely integrated into technical police visual inspections (Guzmán, 2011), it has rarely played a decisive role in underpinning judicial decisions. This situation stems from the lack of specific formal training within police forces, the scarcity of literature in Spanish, and a judicial culture unaccustomed to granting independent probative value to disciplines whose reconstructive nature does not rely on objective laboratory results, but rather on the reasoned interpretation of physical evidence.

This situation is not unique to Spain. Across the countries with a continental European legal tradition, bloodstain pattern analysis (BPA) is significantly less developed than in Anglo-Saxon systems, with the partial exception of some northern European countries—particularly the Netherlands—where investment in forensic science has historically been higher and where significant academic contributions have been made to the international scientific literature (Laan et al., 2014). The absence of a harmonised European system for the accreditation of bloodstain pattern analysis (BPA) experts, comparable to that which exists in the Anglo-Saxon sphere through the International Association of Bloodstain Pattern Analysis (IABPA), partly explains this gap. The European project for the standardisation of forensic science, spearheaded by the European Network of Forensic Science Institutes (ENFSI), has made progress in drawing up best-practice guidelines across various disciplines, although BPA remains among those with the lowest level of regulatory development within the European context. This reality means that national case law, such as that analysed here, takes on additional significance as a reference point for the institutional development of the discipline.

The communicative dimension of BPA is particularly relevant in proceedings before the Jury Court, governed by Organic Law 5/1995 of 22 May. The lay composition of the

jury poses a specific challenge: translating into a verdict the content of a discipline based on physical principles whose intuitive understanding is far from immediate. The expert's clarity of presentation and their ability to link the material evidence to a coherent and verifiable narrative are decisive, not only as a technique of persuasion, but also as a guarantee that the right to effective judicial protection is not compromised by the technical opacity of the evidence.

In this context, the case that took place in Zafra (Badajoz, 2024) constitutes a unique precedent in the Spanish forensic field. In January 2025, a jury found the suspect guilty of murder, and the conviction was upheld in its entirety by the High Court of Justice of Extremadura (TSJ). The regional press explicitly highlighted the role of physical evidence (Reigadas, 2026). As far as this review is concerned, this is one of the few cases in Spain in which the BPA forms the core of the prosecution's case, which justifies its analysis and dissemination within the forensic field.

2. METHODOLOGY

This study follows the design of an observational, descriptive and retrospective case study, the aim of which is the analytical presentation of the bloodstain patterns documented at a crime scene and the assessment of their contribution to the reconstruction of the sequence of events and the evidential process.

The main source of information is the technical police visual inspection carried out at the property where the events took place on 9 July 2024, supplemented by the findings of the post-mortem report and the documentation arising from the court case. The inspection was carried out by a single expert; a circumstance which, in the context of a discipline that is not yet widely established within the forensic units of Spanish police forces, does not constitute a discretionary methodological choice. It should also be noted that the independent verification ideally required by scientific rigour is not satisfied by the mere presence of a second observer at the scene: it requires a second expert with a comparable level of education and training in the discipline, without which the numerical redundancy adds no real analytical value. This circumstance introduces an inherent risk of individual interpretative bias, which is explicitly recognised as a limitation of the analysis.

The visual inspection was carried out in accordance with a protocol of systematic spatial progression, proceeding in a clockwise direction from the main entrance to the property. The evidence was documented using planimetric and elevation metric photography, with a reference scale included in each shot and images taken from multiple angles to preserve the three-dimensional information of the bloodstain patterns.

The documentation of bloodstain patterns followed the terminological and classification criteria established by the SWGSTAIN, taking into account for each stain its morphology, dimensions, orientation, estimated angle of impact and spatial relationship with adjacent evidence. In areas where direct visual inspection proved insufficient due to selective cleaning, chemiluminescent reagents were applied to visualise degraded blood residues.

The trigonometric calculations applied to the projection patterns were carried out manually using trigonometric tables, a procedure equivalent in its mathematical

doi: https://doi.org/10.64217/logosguardiacivil.v4i2.9023 ORCID: 0009-0006-4324-8817

principles to that employed by the specialised computer systems mentioned in the introduction. The angle of impact of each individual stain was determined using the arcsine of the ratio of its width to its length. The determination of the region of origin was carried out in two phases: firstly, the trajectories of the selected stains were projected onto the vertical plane of the wall, yielding the two-dimensional convergence area (X and Y axes on the surface); secondly, by applying the tangent of the angle of impact for each individual stain, the distance from the wall to the projected origin in space was calculated, thereby obtaining the three-dimensional region of origin. The result is not an exact point, but a region or volume whose extent depends on the quality of the measurements, the selection of stains and the physical conditions of the substrate; in BPA, it is methodologically more accurate to speak of a region of origin rather than an exact coordinate, given that traditional trigonometric methods assume rectilinear trajectories and do not natively incorporate the statistical estimation of uncertainty in all three dimensions.

The interpretation of *cast-off-type* patterns on the wall was based on the elongated morphology of the stains, their directional orientation and a distribution consistent with the spattering of blood from a moving object. This interpretation requires a cautious reading of the geometric calculations: unlike passive drip patterns, in which the source can be considered approximately static, *cast-off* involves a dynamic element subject to variables — arc of projection, speed of movement, specific phase of ejection, energy loss and angular variation of the droplets — which determine the morphology and distribution of the resulting stains and limit the precision with which the spatial origin can be estimated

During the projection phase onto the wall surface, eight spots were used to establish the two-dimensional point of convergence. For the three-dimensional trigonometric calculation, however, not all were used: those located in more peripheral areas or further away from the point of convergence were discarded, as they were more influenced by the dynamics inherent to the projection mechanism — arc, velocity and phase of detachment — and offered less reliability for the geometric estimation of the spatial origin. The calculation was limited to the two spots exhibiting the best conditions in terms of ellipticity, perimeter integrity and orientation towards the previously established point of convergence. Those whose trajectories deviated significantly from that point were discarded; the main cause of deviation was the attribution of certain droplets to more than one unit of action—at least two being identified in the analysis of the arc pattern—although inaccuracies inherent in manual measurement may have contributed in individual cases.

The interpretation of the patterns followed an explicit hypothetical-deductive approach. Hypotheses regarding the dynamics of the events—including the exculpatory version put forward by the defence—were formulated prior to the analysis of each piece of evidence, and the compatibility or incompatibility of each finding with these hypotheses was systematically assessed. Hypotheses incompatible with the physical evidence were ruled out in a reasoned and documented manner. As a measure to control for confirmation bias, the criterion of actively seeking evidence that might contradict the working hypothesis was adopted before considering evidence that supported it.

3. CASE DESCRIPTION

The events took place on 9 July 2024 at a property in the town of Zafra (Badajoz). Upon the arrival of the first responders, the victim, a 42-year-old man, was found dead on the public highway in front of the entrance to the property. The body was lying partly in a pool of blood, with visible injuries to the chest, face and left arm, and signs of profuse bleeding from the latter area.

The only person present inside the property at the time of the incident initially gave an account that was inconsistent with the documented findings. According to his account, a third party had assaulted the victim upon opening the front door, and the victim's subsequent movement through the property had been confined to the hallway, where he claimed to have helped him out onto the street. From the very outset of the analysis, this exculpatory account constituted a falsifiable hypothesis: if it were correct, it would have to be consistent with the spatial distribution and chronology of the bloodstain evidence. If the documented patterns proved incompatible with that account, the hypothesis would be refuted by the physical evidence itself, without the need to resort to other forms of evidence.

To put the analysis of the bloodstain patterns into context, it is necessary to refer to the relevant autopsy findings. The victim had multiple stab wounds. The fatal wound was an inciso-puncture wound that penetrated the aorta through the chest wall, causing haemopericardium with cardiac tamponade. Cardiac tamponade causes a rapidly onset, progressive haemodynamic failure: it allows for a brief terminal window of diminishing motor activity—consistent with the victim's subsequent movement—after which collapse ensues, thereby preventing any further purposeful activity. Furthermore, an incised flap wound was observed on the posteroinferior aspect of the proximal third of the left arm, with an exit wound at a short distance; the profuse external bleeding from this wound constituted the main source of the drip pattern documented in the corridor. The correlation between the nature and location of these injuries and the blood patterns identified at the scene constituted one of the central methodological pillars of the reconstructive analysis (Simonin, 1982).

doi: https://doi.org/10.64217/logosguardiacivil.v4i2.9023 ORCID: 0009-0006-4324-8817

4. BLOODSTAIN PATTERNS DOCUMENTED AT THE SCENE

The bloodstain evidence documented in the various rooms of the property is described below, following the order of access during the visual inspection and the clockwise progression applied: hallway, master bedroom and living room. The remaining rooms showed no significant bloodstain evidence.

4.1 HALLWAY

A large number of drip marks were observed in the corridor, visible on both the floor and the side walls. The droplets were predominantly circular and striated in shape (with spiny projections around the edges), and one projection was also visible reaching up to the ceiling. In specific areas, the stains showed signs of skeletalisation, indicating that they had formed earlier than the other patterns that did not exhibit this phenomenon. On the walls, elongated drip marks were identified at low height, as well as contact transfer stains on one of the walls and on the inner surface of the exit door. On the floor, drag marks running longitudinally along the axis of the corridor were observed near that door.

Figure 1.
Drip pattern in the corridor with protruding spikes characteristic of active movement of the source.

Note. Source: Technical-police visual inspection. Zafra (Badajoz), 9 July 2024. The distribution and morphology of the pattern make it possible to determine the direction of movement and its correlation with the injuries to the victim’s left arm.

Figure 2
Drip pattern in the hallway with a directional orientation in the opposite direction to the building's exit.

Note. Source: Technical-police visual inspection. Zafra (Badajoz), 9 July 2024. The direction of the pattern is inconsistent with a direct trajectory towards the exit and is consistent with an initial movement in the opposite direction.

4.2 MASTER BEDROOM

Contact stains were documented on the outer surface of the entrance door. Inside, the door handle was found detached from its mechanism on the floor, with blood transfer on its surface that produced secondary splatters upon impact with the floor. The rest of the floor showed no further macroscopic evidence.

On the furniture, transfer stains were identified on the bed linen and on the cover of a book. Isolated droplets were found on a cushion, the ceiling and various objects on the bedside table. Following the application of chemiluminescent reagents, a large, diffuse stain was revealed on the floor beneath the bed; its straight-lined outline coincided with the position of the bed's crossbar and footboard, the latter of which was broken. Damage was also documented to the ceiling light fitting, which had partially come loose from its mounting; two drops found on it tested positive with the presumptive reagent.

On the front wall, at the level of the headboard, two low-velocity spatter patterns were identified, consistent with a 'cast-off' projection mechanism, resulting from the inertial ejection of blood previously accumulated on the blade of the weapon during contact with the victim's head region, with the victim's defensive interception of the weapon being the mechanism that triggered the blood ejection and determined both the morphology and extent of each pattern (Bevel & Gardner, 2008; James et al., 2005): the linear pattern is consistent with a downward and anteroposterior trajectory interrupted at the initial phase of the swing; the arched pattern, extending from the ceiling to the floor, with a full arm swing that was likewise interrupted during its course, which explains the projection of blood towards the ceiling and the objects on the bedside table.

doi: https://doi.org/10.64217/logosguardiacivil.v4i2.9023 ORCID: 0009-0006-4324-8817

To determine the three-dimensional region of origin of the arc-shaped pattern, the procedure described in the methodology section was followed: eight splatter marks projected onto the wall to establish the two-dimensional point of convergence, and two splatter marks selected for the three-dimensional trigonometric calculation. These had impact angles of 23.58° and 14.48°, with distances to the point of convergence of 20 cm and 28 cm respectively. Applying the relationship Z = distance × tan α, estimates of 8.72 cm and 7.23 cm from the wall were obtained, with an average value of approximately 8 cm. This result did not constitute a precise localisation of the source, but rather a rough estimate of the spatial area consistent with the ejection of the analysed droplets; its value lies in its consistency with the orientation of the stains, the point of convergence and a projection dynamic occurring in the immediate vicinity of the wall, notwithstanding the margin of uncertainty inherent in the analysis of a *cast-off* pattern. The distance measured from the point of convergence to the surface of the pillow was approximately 34 cm; given that the pillow was approximately 16 cm thick—significantly reduced by the compression exerted by the weight of the head—this set of data was spatially consistent with the victim's head position on the right-hand side of the bed.

Figure 3

General view of the master bedroom during the visual inspection, showing the condition of the room following the events.

Note. Source: Technical-police visual inspection. Zafra (Badajoz), 9 July 2024. The image shows the absence of macroscopic bloodstains on the floor —consistent with subsequent selective cle — the broken footboard of the bed, the cushion placed on top of the pillow, and the general rearrangement of the furniture. Taken together, these elements proved decisive in inferring the possible tampering with the scene and reconstructing the sequence of events that took place in this room.

4.3 LIVING ROOM

In this room, isolated drops were documented on the floor converging towards an area adjacent to a sofa, on which transfer stains were identified near an area of higher droplet density. In the immediate vicinity, a streak of transferred blood was found, the morphology of which matched the stain identified on the room's light switch.

Figure 4

Partial view of the living room during the visual inspection.

Note. Source: Technical-police visual inspection. Zafra (Badajoz), 9 July 2024. The figure documents the bloodstains in the room, the chronology and morphology of which proved relevant to the analysis of the subsequent re-entry into the property.

5. DISCUSSION

The reconstruction of the sequence of events most consistent with the body of documented bloodstain evidence is based on the following inferences. The density and heterogeneity of the bloodstains place the initial scene in the master bedroom. Analysis of the arc-shaped pattern—eight bloodstains used for two-dimensional convergence on the wall, of which two were selected for the three-dimensional trigonometric calculation—determined a distance from the wall of approximately 8 cm, a rough estimate consistent with a projection originating in the vicinity of the headboard. Direct measurement from the point of convergence to the surface of the pillow, taken into account alongside the pillow's reduced thickness due to compression from the weight of the head, reinforces the spatial consistency between the pattern's point of origin and the victim's head position on the right-hand side of the bed. It should be emphasised that this location does not constitute a precise determination, but rather the most plausible hypothesis from the point of view of the convergence of trajectories and the calculations carried out, consistent with the body of corroborating evidence in that area of the room.

The linear pattern—with no defined point of convergence—is situated 10 cm above the cushion, which is interpreted as an element that raised the victim's head region. The two cast-off patterns, described in the section on bloodstain patterns, are consistent with the dynamics of the attack, in which the victim's defensive interception of the weapon determined both the morphology and the extent of each pattern; the full-arc pattern—from the ceiling to the floor—is, in this regard, the most telling indicator of the interaction between the assailant and the victim.

doi: https://doi.org/10.64217/logosguardiacivil.v4i2.9023 ORCID: 0009-0006-4324-8817

Integrating these patterns with the autopsy findings allows us to determine the dynamics of the fatal injury. Its trajectory—perpendicular and horizontal—is biomechanically incompatible with an attack carried out whilst both parties were standing, and is consistent with the assailant being in a higher position relative to the victim. The distribution of the marks on the wall at the head of the bed, on the ceiling, on the lampshade and the objects on the bedside table, and on the floor on the same side, is consistent with the marks being caused whilst the victim was lying on the bed and the assailant was positioned above her. The hypothesis most consistent with the body of evidence places the fatal chest injury at the moment when the victim, following the initial head injuries, was attempting to sit up to leave the room; this explains both the trajectory described and the possibility of subsequent movement documented by the patterns in the corridor.

The diffuse morphology of the stains revealed on the bedroom floor is consistent with mechanical disturbance caused by cleaning (Raffo, 2006). The blood pattern preserved under the bed, revealed using chemiluminescent reagents, is consistent with the floor having been cleaned whilst the bed was in a position displaced from that observed at the start of the inspection. The chemiluminescent reaction showed a straight boundary corresponding to the position of the bed frame during the cleaning operation: the mop handle, upon coming into contact with the crossbar as it reached that point, determined the limit to which the cleaning extended and recorded the position of the bed at that time. The fact that the bed was moved during the events is corroborated by the broken footboard; the fact that it was repositioned after the cleaning is supported by the discrepancy between its final position and that revealed by the chemiluminescent reaction.

The overall pattern of bloodstains in the bedroom is consistent with the source of the blood being situated above the victim, who would initially have been lying on her back occupying the right-hand half of the bed, demarcated by the book situated in the centre of the bed, the cover of which tested positive for the presumptive reagent. The evidence is also consistent with the victim sitting up and closing the room's door — as inferred from the transfer pattern on the handle and the passive dripping documented beneath the light switch — and with a pulling force being exerted on the door that caused the handle to detach from its mechanism. The eight incisions identified on the inner surface of the door leaf support the hypothesis of a harmful action directed towards the obstacle preventing exit from the room.

Once in the corridor, the documented patterns are consistent with a further injury to the left arm, which produced a drip pattern associated with the active movement of a bleeding source whilst the upper limb was swinging. The absence of this trace in the bedroom allows this injury to be placed chronologically after the door was closed. The direction of the drip—away from the exit— is consistent with an initial movement away from the entrance, and the drag marks near the front door, the contact transfers on the wall and the inner surface of the door, and the vertical sliding pattern, are consistent with a progressive collapse in the vicinity of the threshold. All evidence suggests that the victim managed to reach the public thoroughfare, where death occurred.

The blood patterns in the living room show a chronology consistent with a perimortem or early post-mortem phase, occurring after death on the public thoroughfare. The findings include a small drip at the entrance, a localised pool next to the sofa and a

transfer stain consistent with manual contact on the sofa itself, as well as drips and contact marks on a floor-level power strip. These indications are not consistent with the victim being the source of the blood: once the collapse resulting from the described blockage had occurred and death had taken place on the public highway, any deliberate motor activity—including the handling of a power strip—was ruled out. The sequence of findings is most plausibly explained by a third person re-entering the property to retrieve personal belongings, a circumstance which was admitted by the person under investigation.

The presence of skeletalised stains in the corridor (Laan et al., 2014) points to a re-entry into the property prior to the evidence having dried completely. It was during this re-entry that the selective cleaning work, inferred from the chemiluminescent patterns in the bedroom, would have taken place. The correct interpretation of these patterns also requires an adequate understanding of the physical principles governing the behaviour of blood as a fluid, an aspect whose explanation proved decisive for the jury's understanding during the plenary session.

5.1 SCIENTIFIC RELIABILITY OF BPA AND INTERNATIONAL VALIDATION STANDARDS

One of the issues most frequently raised in the procedural debate surrounding BPA is its reliability as a science, understood as its ability to generate reproducible and verifiable conclusions. The NAS report (2009) noted that, although BPA is based on sound physical principles, many inferences in forensic practice lacked the empirical support necessary to be considered scientifically sufficient. The criticism was particularly incisive regarding conclusions on the mechanism of production, a field in which variability among experts showed levels of discordance that compromised the reliability of individual expert reports.

Current debates in the specialist literature address issues such as error rates in pattern classification, inter-observer variability and contextual bias—that is, the analyst's tendency to interpret evidence in light of prior information about the case. These discussions do not invalidate the discipline, but they do require that its conclusions be presented with a degree of certainty justified by the evidence, clearly distinguishing between what the patterns allow us to assert and what can only be formulated as a hypothesis compatible with the available data.

Landmark studies such as that by Taylor et al. (2016) have analysed the reliability of pattern classification on rigid, non-absorbent surfaces, concluding that certain categories exhibit acceptable levels of inter-observer agreement when analysts apply standardised terminological criteria, whilst others— , particularly those linked to combined mechanisms or scenes with deliberate alterations—show higher levels of disagreement. Attinger et al. (2013) have contributed, from the perspective of fluid dynamics, to establishing the physical principles of BPA within a reproducible experimental framework. In response to these shortcomings, the OSAC Bloodstain Pattern Analysis Scientific Area Committee has made progress in defining standardised vocabulary, documentation procedures and interpretation criteria that reduce variability between analysts. It is currently considered that BPA achieves its maximum reliability when its conclusions are presented in terms of compatibility with the observed patterns,

doi: https://doi.org/10.64217/logosguardiacivil.v4i2.9023 ORCID: 0009-0006-4324-8817

rather than absolute certainty, and when they are integrated into the overall analysis of the crime scene without constituting the sole basis for reconstructive reasoning.

5.2 BPA IN THE SPANISH PROCEDURAL SYSTEM

The role of the BPA in Spanish procedural practice raises considerations that go beyond the technical accuracy of the expert report. The expert acted in the capacity of a civil servant attached to the Forensic Science Unit, which confers on his opinion a presumption of impartiality that cannot be said, to the same extent, of a party-appointed expert. This distinction, whilst procedurally relevant, does not eliminate the need for a conscious and documented methodological approach: objectivity is the result of an explicit procedure, not an automatic consequence of civil servant status.

The strength of the conclusions reached in the plenary session lay not in their rhetorical force, but in the impossibility of formulating an alternative hypothesis that was equally compatible with all the documented evidence. This characteristic — the BPA's ability to act as a means of falsifying the hypotheses under consideration — constitutes its most specific contribution to the judicial process. The procedural impact was further enhanced by a combination of circumstances that placed the BPA in a position of particular significance within the body of evidence: the absence of direct witnesses, the existence of conflicting hypotheses and the limited conclusiveness of other expert reports created a context in which the analysis of bloodstain patterns acted as the main framework for the factual reconstruction.

5.3 INHERENT LIMITATIONS OF THE ANALYSIS

The limitations of the analysis are twofold. The first concerns the physical conditions of the crime scene: the documented evidence is consistent with the scene having been deliberately tampered with prior to the arrival of the investigators, a circumstance which reduced both the quantity and quality of the available information. The methodology applied, including chemiluminescence, enabled the recovery of partial information, but not equivalent to that which an intact crime scene would have provided.

The second limitation is of a disciplinary nature: forensic analysis is an interpretative discipline whose results constitute reasoned inferences based on physical principles and observable measurements, not absolute determinations with a fully quantified margin of error in all cases. The robustness of the conclusions therefore depends on the internal consistency of the analysis and the rigour with which plausible alternative hypotheses have been ruled out, two aspects explicitly addressed in this study.

6. CONCLUSIONS

The analysis of the bloodstain patterns documented in the Zafra case made it possible to reconstruct the sequence of events most consistent with the physical evidence: the location of the initial scene in the master bedroom, the victim's position on the bed determined by trigonometric calculation of the *cast-off* patterns, the sequence of movements through the corridor, the signs of selective cleaning, and the subsequent re-entry into the property. Each of these inferences was tested against the alternative hypotheses put forward during the proceedings, with the exculpatory version proving incompatible with the physical distribution of the evidence as a whole.

The case illustrates the potential of the BPA when it acts as the structural framework for the assessment of evidence in the absence of direct evidence or more conclusive biological evidence. Its most specific contribution did not lie in directly establishing the perpetrator's identity, but in demonstrating the physical incompatibility of the alternative hypothesis, acting as an instrument of epistemological contrast between contradictory accounts. The presentation of the conclusions in terms of compatibility and consistency, rather than categorical certainty, did not weaken the probative value of the analysis: on the contrary, it reinforced its methodological credibility before the jury and demonstrated the rigour with which it was conducted.

The analysis also demonstrates that the BPA can produce results of high reconstructive value using a manual methodology supported by trigonometry, without the need for specialised computer tools, provided that the procedure is systematic, documented and transparent regarding its margins of uncertainty. This does not negate the desirability of equipping forensic units with resources commensurate with the state of the discipline at an international level, but it does demonstrate that a lack of equipment is no obstacle to a scientifically rigorous analysis.

From the perspective of forensic policy, the case highlights the need to advance the institutionalisation of BPA in Spain through formal training and certification standards. The dissemination of cases such as the one analysed here may help to raise awareness of the discipline's potential within the Spanish forensic and judicial spheres, stimulating academic and institutional interest in a specialisation which, to date, has remained too confined to individual initiative.

ETHICAL STATEMENT

The case analysed here was heard before the Provincial Court of Badajoz, resulting in a conviction which was appealed against and upheld in its entirety by the High Court of Justice of Extremadura. The case has passed the stage of ordinary appeal; should a cassation appeal be lodged with the Supreme Court, its scope would not extend to the assessment of the evidence as pre-established evidence nor to the facts found to be proven by the jury. The facts and their circumstances are in the public domain, having been the subject of extensive coverage in the print and broadcast media, with public dissemination of the images of the scene, which also form part of the court case. The photographs included in this paper do not contain images of identifiable individuals. The author acted in this case in his capacity as a civil servant performing his duties as an expert witness. The sole purpose of publishing this paper is the scientific dissemination of the methodology and findings, for the benefit of advancing the discipline within the Spanish forensic field.

CONFLICT OF INTEREST

The author declares that he has no conflict of interest, whether financial or otherwise, in relation to the content of this paper or the process of its publication.

doi: https://doi.org/10.64217/logosguardiacivil.v4i2.9023 ORCID: 0009-0006-4324-8817

REFERENCES

Attinger, D., Moore, C., Donaldson, A., Jafari, A., & Stone, H. A. (2013). Fluid dynamics topics in bloodstain pattern analysis: Comparative review and research opportunities. Forensic Science International, 231(1–3), 375–396.

Balthazard, V. (1939). Étude des gouttes de sang projetées. Annales de médecine légale, de criminologie et de police scientifique, 19, 241–268.

Bevel, T., & Gardner, R. M. (2008). Bloodstain pattern analysis with an introduction to crime scene reconstruction (3rd ed.). CRC Press.

Guzmán, C. A. (2011). Crime scene examination: Methodology of visual inspection. Editorial B de F.

James, S. H., Kish, P. E., & Sutton, T. P. (2005). Principles of bloodstain pattern analysis: Theory and practice. CRC Press.

Kirk, P. L. (1955). Crime investigation. John Wiley & Sons.

Laan, N., de Bruin, K. G., Slenter, D., Wilhelm, J., Jermy, M., & Bonn, D. (2014). Bloodstain pattern analysis: The gravity of the situation. Forensic Science International, 243, 70–77.

National Academy of Sciences (NAS). (2009). Strengthening forensic science in the United States: A path forward. The National Academies Press.

Piotrowski, E. (1895). On the origin, shape, direction and spread of bloodstains following cuts to the head. Virchows Archiv, 142, 1–21.

President's Council of Advisors on Science and Technology (PCAST). (2016). Forensic science in criminal courts: Ensuring scientific validity of feature-comparison methods. Executive Office of the President of the United States.

Raffo, O. H. (2006). The Measure of Blood: The Analysis of Bloodstains at the Crime Scene. Editores del Puerto.

Reigadas, N. (2026, 7 March). The bloodstain that convicted […]. Diario HOY.

Simonin, C. (1982). Forensic Medicine. Jims.

Taylor, M. C., Laber, T. L., Kish, P. E., Owens, G., & Osborne, N. K. P. (2016). The reliability of pattern classification in bloodstain pattern analysis — Part 1: Bloodstain patterns on rigid non-absorbent surfaces. Journal of Forensic Sciences, 61(4), 922–927.

LEGISLATION

Code of Criminal Procedure. Royal Decree of 14 September 1882. Official State Gazette, 17 September 1882, no. 260. [With the amendments introduced up to the date of publication of this paper.]

Organic Law 5/1995 of 22 May on the Jury Court. Official State Gazette, 23 May 1995, No. 122, pp. 14962–14979.

doi: https://doi.org/10.64217/logosguardiacivil.v4i2.9023 ORCID: 0009-0006-4324-8817