PHYSICAL ANALYSIS OF BLOOD SPATTER PATTERN ON CONCRETE WALL

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A special dedication to my beloved mother and father, my supervisor Mr. Hashim Baharin, and my Co-supervisor Superintendent Soo Me Tong.

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ABSTRACT

Bloodstain pattern analysis is the study and investigation of the physical characteristics of blood spatter in order to reconstruct a crime scene event especially homicide crime scene. This study aims to analyze blood stain patterns on non-porous wall by using real blood which mainly focused in the comparison of impact spatter between several parameters. The parameters involved were in term of amount of blood, velocity, position of victim, distance, porosity of surfaces and directionality. In this study is undertaken to analyze cast-off stain (linear spatter), impact spatter (non-linear spatter) and drip (non-linear spatter) which caused by both sharp weapon and blunt weapon. The bloodstain pattern was produced by hit the blood-soaked sponge with weapon and swung back and forth in overhead. Results showed that as amount of blood increased as the number of drops and total coverage area increased. Total coverage area also affected by the various distances to wall; greater separation was found when the distance was further. In comparison of velocity, higher velocity was tended to generate finer droplets and vice versa. Bloodstain on porous surface and non-porous surface had significant difference as more blood drips were found on non-porous wall surface. For the area of convergence determination, result showed that impact angle was proportional to width to length ratio of blood drops. As impact angle decreased, the stain was found more elongated in shape. Minimum number of blow on and sequence of blow on cast-off stain was determined through the blood trails. Based on this study, impact spatter in term of velocity, directionality, position of victim, distance, blood volume, and porosity of surfaces can be differentiated. Area of convergence and impact angle can also be determined by using stringing method and mathematical method respectively.

ABSTRAK

Analisa corak kesan darah adalah kajian dan penyiasatan ciri-ciri fizikal percikan darah dalam usaha untuk membina semula urutan tempat kejadian jenayah terutama pembunuhan jenayah. Kajian ini bertujuan untuk menganalisis corak kesan darah pada dinding bukan berliang dengan menggunakan darah tulen yang terutamanya tertumpu dalam perbandingan kesan percikan antara beberapa parameter. Parameter yang terlibat adalah kuantiti darah, halaju, kedudukan mangsa, jarak, keliangan permukaan dan arah. Corak kesan darah telah dihasilkan dengan memukul span yang direndam darah oleh senjata dan mengayunkan ke belakang dan ke hadapan. Keputusan menunjukkan bahawa semasa kuantiti darah meningkat, bilangan titisan dan jumlah kawasan liputan juga meningkat. Jumlah kawasan liputan juga dipengaruhi oleh pelbagai jarak ke dinding; pemisahan titisan darah yang lebih besar telah ditemui apabila jarak semakin jauh dari dinding. Dalam perbandingan halaju, halaju yang lebih tinggi cenderung untuk menghasilkan titisan halus dan sebaliknya. Kesan darah pada permukaan berliang dan permukaan tidak berliang mempunyai perbezaan yang ketara. Dimana bahawa darah jenis menitis lebih banyak ditemui pada permukaan dinding tidak berliang. Bagi penentuan kawasan penumpuan, keputusan menunjukkan bahawa sudut hentaman adalah berkadar kepada nisbah lebar dan panjang titisan darah. Sudut hentaman yang lebih mencondong menghasilkan titisan darah yang memanjang dalam bentuk. Bilangan minimum tamparan dan urutan tamparan juga telah ditentukan melalui corak kesan darah. Berdasarkan kajian ini, kesan percikan dalam jangka halaju, arah, kedudukan mangsa, jarak, kuantiti darah, dan keliangan permukaan boleh dibezakan. Kawasan penumpuan dan sudut hentaman masing-masing boleh ditentukan dengan menggunakan kaedah benang dan kaedah matematik.

TABLE OF CONTENTS

CHAPTER	TITLE		PAGE
	DECLARATION		ii
	DEDICATION		iii
	ACKNOWLEDGEMENTS		iv
	ABSTRACT		v
	ABSTRAK		vi
	TABLE OF CONTENTS		vii
	LIST OF TABLES		xi
	LIST OF FIGURES		xii
	LIST OF ABBREVIATIONS		xv
	INTRODUCTION		**1**
1	1.1	Preamble	1
	1.2	Problem Statement	2
	1.3	Research Objectives	3
	1.4	Hypothesis Statement	3
	1.5	Significance of Study	3
	1.6	Scope of Study	4
	LITERATURE REVIEW		**5**
2	2.1	Introduction	5
	2.2	Amount of Droplet and Source Factor	6
	2.3	Classification of Bloodstain Patterns	6

	2.4	Blood Movement Characteristics	6
	2.5	Transfer Bloodstains	7
	2.6	Identifiable Transfer Bloodstains	8
	2.7	Impact Spatter Mechanisms	9
	2.8	Bloodstains Spatter Related with Hitting and Piercing Actions	9
	2.9	Cast-off Bloodstains	10
	2.10	Area of Convergence	12
	2.11	Point of Origin	13
	2.12	Factor Affected Bloodstains Spatter	13
	2.13	Choice of Ideal Bloodstains	14
	2.14	Documentation	14
	2.15	Trigonometric Method	15
	2.16	Importance of Mathematical Analysis of Bloodstain Pattern Evidence	15
	2.17	Blood Spatter Pattern and Velocity	16
	EXPERIMENTAL		**17**
3	3.1	Introduction	17
	3.2	Materials and Samples	17
	3.3	Equipments and Apparatus	18
	3.4	Procedure	20
		3.4.1 Effect of Blood Volume	20
		3.4.2 Effect of Distance of Blood Source to Wall	21
		3.4.3 Effect of Cast-off Directions	22
		3.4.4 Effect of Relative Position of Blood Source	22
		3.4.5 Effect of Different Velocities	22

	3.4.6	Comparison between Porous and Non-porous Wall Surfaces	23
	3.4.7	Comparison between Drop Volumes of Different Source Object	23
	3.4.8	Comparison of Flow Patterns on Wall Surfaces	24
	3.4.9	Determination of Area of Convergence	24
	3.4.10	Angle of Impact	25
	3.4.11	Overhead Cast-off Stain	25
4	**RESULTS AND DISCUSSION**		**26**
	4.1	Introduction	26
	4.2	Impact Spatter	26
	4.2.1	Effect of Blood Volume	27
	4.2.2	Effect of Distance of Blood Source to Wall	30
	4.2.3	Effect of Cast-off Directions	35
	4.2.4	Effect of Relative Position of Blood Source	38
	4.2.5	Effect of Different Velocities	41
	4.2.6	Comparison between Porous and Non-porous Wall Surfaces	43
	4.3	Comparison between Drop Volumes of Different Source Object	44
	4.4	Comparison of Flow Patterns on Wall Surfaces	46
	4.5	Determination of Area of Convergence	47
	4.6	Angle of Impact	49
	4.7	Overhead Cast-off Stain	52
	4.8	Analysis of Real Crime Scene Photos	53
	4.9	Limitation of the Study	56

5 CONCLUSIONS AND RECOMMENDATIONS **57**

5.1 Conclusions 57

5.2 Suggestions and Recommendations 60

REFERENCES **61**

APPENDIX **64**

LISTS OF TABLES

TABLE NO.	TITLE	PAGE
3.1	Length and width of weapon and blade	19
4.1	Comparison between amounts of blood produced by hammer	27
4.2	Comparison between amounts of blood produced by chopper	27
4.3	Comparison of total coverage area between different distances and mechanisms	31
4.4	Comparison between higher velocity and lower velocity	42
4.5	Differences in Drop Volume Produced by the Source Object	44
4.6	Area of convergence data	47

LISTS OF FIGURES

FIGURE NO.	TITLE	PAGE
3.1	Screened and expired human blood sample	18
3.2	Personal protective wear	19
3.3	Six types of weapons used (a) machete, (b) chopper, (c) knife, (d) hammer, (e) screwdriver, (f) spanner	20
3.4	Weapon swung on the sponge	21
3.5	Weapon was swung at angle 30 °, 60 °and 90 ° respectively.	25
4.1	Bloodstains spatter produced by blunt weapon (hammer) distributed on a concrete wall using (a) 20 mL of blood, (b) 40 mL of blood, and (c) 60 mL of blood	28
4.2	Bloodstains spatter produced by sharp weapon (chopper) distributed on a concrete wall using (a) 20 mL of blood, (b) 40 mL of blood, and (c) 60 mL of blood	29
4.3	Bloodstain pattern produced by blunt weapon (hammer) at three various distances from wall (a) 48 inches, (b) 54 inches, (c) 60 inches	32
4.4	Bloodstain pattern produced by sharp weapon (chopper) at three various distances from wall (a) 48 inches, (b) 54 inches, (c) 60 inches	33
4.5	Bloodstain pattern produced by mouse trap at three various distances from wall (a) 48 inches, (b) 54 inches, (c) 60 inches	34

4.6	Directionality of cast-off stains produced by a hammer when struck (a) from left to right, (b) perpendicular, and (c) from right to left	35
4.7	Demonstrated that the cast-off stains were produced by the chopper as struck (a) from left to right, (b) perpendicular, and (c) from right to left	36
4.8	Bloodstains spatter were dispersed to wall when blow on a blood source by using the hammer (a) from left to right, (b) perpendicular, and (c) from right to left	36
4.9	Bloodstains spatter were dispersed to wall when blow on a blood source by using the mouse trap (a) from left to right, (b) perpendicular, and (c) from right to left	37
4.10	The focus view of bloodstain droplets that were travelling from (a) Right to left after striking a flat level surface, (b) Left to right after striking a flat level surface	37
4.11	Bloodstain pattern produced by blunt weapon (hammer) at (a) Ground level, (b) Higher level position	39
4.12	Bloodstain pattern produced by sharp weapon (chopper) at (a) Ground level, (b) Higher level position	39
4.13	Bloodstain pattern produced by mouse trap at (a) Ground level, (b) Higher level position	40
4.14	Void area shows in arrow	40
4.15	Blood spatter produced by blunt weapon (hammer) for comparing different velocity; (a) Higher velocity, (b) Lower velocity	41
4.16	Blood spatter produced by sharp weapon (chopper) for comparing different velocity; (a) Higher velocity, (b) Lower velocity	42
4.17	Blood spatters produced by blunt weapon (hammer) on (a) Non-waterproof wall, (b) Waterproof wall	43

4.18	Single drop of human blood that fell to smooth cardboard from 1 meter height which produced by (a) Hammer Head, (b) Thumb, (c) Index Finger, (d) Chopper, (e) Spanner, (f) Hammer Claw, (g) Screwdriver, (h) Machete, (i) Knife	45
4.19	Different flow patterns (a) Single flow pattern on smooth wall, (b) Flow pattern on specific wall texture	46
4.20	Point of converging of individual stains within a spatter on concrete wall. A circle indicated on the figure represents the point of converging	48
4.21	Determination of the point of convergence of bloodstains at a scene with the use of strings through central axis of the bloodstains	48
4.22	The leading edges and terminal edges of bloodstain	49
4.23	The measurement of a circular bloodstain	50
4.24	The measurement of an elongated bloodstain	50
4.25	The measurement of a more elongated bloodstain	50
4.26	Impact angle was calculated by using trigonometric method.	51
4.27	Blood drop created by hammer swung with angle 30 °	52
4.28	The cast-off patterns comprising of elongated bloodstains shown blow's sequence and directionality from right to left.	52
4.29	Blood spatter on wall at crime scene 1	53
4.30	Blood spatter on wall at crime scene 2	54
4.31	Blood spatter on wall at crime scene 3	55
4.32	Blood spatter on wall at crime scene 4	56

LISTS OF ABBREVIATIONS

Cm	-	Centimeter
Cm^2	-	Centimeter Square
Ft	-	Feet
HSA	-	Hospital Sultanah Aminah
In	-	Inches
mL	-	Milliliter
Mm	-	Millimeter
sec	-	Seconds
W/L	-	Width/Length
°	-	Degree

CHAPTER 1

INTRODUCTION

1.1 Preamble

Blood spatters determinations are the inspection of the physical dimension, positions, and spreading or spurting model of blood spatter, for the sake of furnishing the evaluation of the external occurrences which could lead to original source. Bloodstains pattern analysis is an amazing investigation apparatus can be applied in reconstructing crime scene events. If a forensic scientist apprehends blood reacts in what manner during it exposing from a human body, and response in what manner during it touching a plane, subsequently an assumption is able to make to apprehend what was occurred and to decide if an offense taken place. An expert forensic investigator always would observe on the blood distributions produced by cast blood and try to reconstruct what was occurred.

Analyzing of blood spatters comprises external measuring of blood drops, spatter identification employing verified images or tests, the utilization of trigonometric method, and information of the movement's physic. By making good use of others form of crime scene evidences such as palm prints, instruments' mark, tyre prints impressions, biological evidences, chemical examination, and others. A forensic investigation team would gather all related evidences to re-generate a reasonable flow of a crime, and this is defended by others form of crime evidences.

The general practice of bloodstains spatter model examination reflects the elements of position, form, physical dimension, spreading patterns and others more

external behaviour of the blood spatters in a crime scene. However, blood patterns are a cluster of single bloodstain produced with the similar strike and the strength used. Greater parts of the bloodstains spatters of a model would suit in a reasonable physical dimension extent on a provided spatters classification. In the easiest structure, the spatter can be generated by a individual striking of consistent speed. For this example, a single blood spatter would emit far from the location of striking in a fan-like structure or dispersion of radiate. A whole blood distribution models are affected by several elements consisting, however unrestraint to the speed of certain striking strength, the direction of the administered power, an exterior patterns of an injury giving a blood origin, exterior structure, and blockage existed at the physical surrounding.

1.2 Problem Statement

Bloodstains are existed at majority of the crime areas implicating anger would consequently provide the forensic investigators with extra knowledge to identify the crime's flows, from which might be taken involved betwixt the suspect and also the victim. Currently, bloodstains spatter in crime scene as well as bloodstains from either suspect or victim's clothes can be very helpful in order to use in assuring or discredit an uncertain conclusion relating with crime events and the flows. However, bloodstains spatter patterns are difficult to link with the possible weapon used as to whether blunt weapon or sharp weapon are used.

Furthermore, there is little research done on bloodstain patterns analysis on painted concrete wall. This is due to the large painted wall is not easy to be accessed in a normal research laboratory. Therefore, for the sake to make sure the restoration of bloodstain proof or clue we need to understand the physical properties of bloodstain pattern and proper documenting must be done.

1.3 Research Objectives

Objectives for this research are:

i. To compare the impact spatter of bloodstains in terms of directionality, velocity, impact angle, position of blood source, distances, blood volume, and porosity of surfaces.

ii. To determine the point of convergence, impact angle, minimum number of blow, and sequence of blow of bloodstains on wall.

1.4 Hypothesis Statement

The area of convergence can be determined from bloodstains by using string method and mathematical calculation. The directionality, velocity, impact angle, position of victim, distances, blood volume, and porosity of surfaces can be differentiated from the various bloodstain patterns on wall. Analysis of bloodstains pattern can reveal information regarding minimum number of blow, and sequence of blow on wall.

1.5 Significance of Study

Blood spatter can always be found easily in most of the crime scene especially for both sexual assault and homicide cases. Therefore, this study is essential for investigator in reconstructing the whole crime event in which the bloodstain spatter pattern analysis can act an important role. Generally, this study could be used to assist them in determining the point of convergence, position of blood source, and possible type of weapon used.

1.6 Scope of Study

In this research, the surface matrices used is mainly focus on brick wall. Two major categories of weapons used are blunt objects and sharp objects respectively. Further studies were made by conducting a series of bloodstains pattern analysis which encompasses the impact angle, position of victim, area of convergence and the sequence interpretation of bloodstains pattern.

REFERENCES

Bevel, V. T. and Gardner, R. M. (2008). Bloodstain Pattern Analysis: With an Introduction to Crime Scene Reconstruction. 3rd edition. Boca Raton, FL: CRC Press. 1-14.

Buck, U., Kneubuehl, B., Näther, S., Albertini, N., Schmidt, L. and Thali, M. (2011). 3D Bloodstain Pattern Analysis: Ballistic Reconstruction of the Trajectories of Blood Drops and Determination of the Centres of Origin of the Bloodstains. *Forensic Sci. Int.* 206:22–28.

Carter, A. L. (2001). The Directional Analysis of Bloodstain Patterns—Theory and Experimental Validation. *Can. Soc. Forensic Sci. J.* 34(4):173–89.

Chong, M. H. (2010). Comparison of Real Blood and Synthetic Blood for Blood Spatter Pattern Determination on Various Matrices. Master of Science Dissertation Report, Universiti Teknologi Malaysia, Skudai.

Deforest, P. R. (1990). A Review of Interpretation of Bloodstain Evidence at Crime Scenes, *J. Forensic Sci*., 35, 1491-1495.

Fish, J. T., Miller, L. S. and Braswell, M. C. (2010). Crime Scene Investigation. 2nd edition. Burlington, MA: Elsevier. 163-164.

Gardener, R. M. (2002). Directionality in Swipe Patterns. *J. Forensic Ident*. 52(5):579-593.

Hess, K. M., Orthmann, C. H. and Orthmann-hess, C. (2009). Criminal Investigation, 9th Ed., 149.

Knock, C. and Davidson, M. (2007). Predicting the Position of the Source of Blood Stains for Angled Impacts, *J. Forensic Sci*., 52, 1044-1049.

Laber, T. L. (1985). Diameter of a Bloodstain as a Function of Origin. Distance Fallen and Volume of Drop. IABPA News 2(1):12–16.

Laber, T. L. and Epstein B. P. (1983). Bloodstain Pattern Analysis. Callen Publishing Company, Minneapolis, Minnesota.

Langford, A., Dean, J., Reed, R., Holmes, D., Weyers, J. and Jones, A. (2005). Practical Skills in Forensic Science. *Pearson, Prentice Hall: London.*

Lissitzy, C. B. (2008). Blood Spatter Analysis. Forensic Science. Pasadena, California and Hackensack, New Jersey: *Salem Press, Inc*. 155-157.

MacDonell, H. L. (1982). Bloodstain Pattern Interpretation. New York: Laboratory of Forensic Science Publishers.

MacDonell, H. L. (1993). Bloodstain Patterns. New York: Laboratory of Forensic Science. Corning, New York.

Peschel, O., Kunz, S. N., Rothschild, M. A. and Mützel, E. (2011). Blood Stain Pattern Analysis. *Forensic Sci. Med. Pathol.* 7(3):257–270.

Pizzola, P. A., Roth, S. and Deforest, P. R. (1986). Blood Droplet Dynamics—II. *J. Forensic Sci.* 31(1):50–64.

Raymond, M. A., Smith, E. R. and Liesegang, J. (1996). The Physical Properties of Blood—Forensic Considerations. *Sci. & Justice* 36:153–160.

Rowe, W. F. (2006). Errors in the Determination of the Point of Origin of Bloodstains *Forensic Sci. Int.*, 161, 47-51.

Matisoff, M. and Barksdale, L. (2012). Mathematical and Statistical Analysis of Bloodstain Pattern Evidence: Origin of Impact. *J. Forensic Sci*., 21(1): 26-30.

Stuart, H. J., Kish, P. E. and Sutton, T. P. (2005). Principles of Bloodstain Pattern Analysis. Theory and Practice, Taylor & Francis: Boca Raton.

White, R. B. (1986). Bloodstain Pattern of Fabrics—the Effect of Drop Volume, Dropping Height and Impact Angle. *J. Can. Soc. Forensic Sci.* 19(1):3–36.

William, G. E. and Stuart, H. J. (1993). Interpretation of Bloodstain Evidence at Crime Scenes. New York: CRC Press, Inc. 11-66.

Wilson, C. I., Altschul, S, Mead, A. and Flannagan, L. M. (2004). Bloodstain Pattern Analysis in a Case of Suicide with a Compound Bow and Arrow. *Am. J. Forensic Med. Pathol.* 25:80–82.

Wolson, T. L. (1995). Documentation of Bloodstain Pattern Evidence. *J. Forensic Ident*. 45(4):396–408.

Wolson, T. L. (2000). Bloodstain Pattern Analysis. Miami-Dade Police Department, Miami. Encyclopedia of Forensic Sciences, 1st Ed., Academic Press, 1337-1348.

Wonder, A. Y. (2007). Bloodstain Pattern Evidence: Objective Approaches and Application. Academic Press, San Diego. 277-301.