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Determination of Shape and Angle of Blood Drop Pattern In Relation To Height on Different Surfaces

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Abstract: *Blood drops and blood drop pattern are some of the most common form of physical evidence encountered during the forensic investigation of incidents involving violence against a person. This study was carried out at Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad. The purpose of the study to determine the angle and shape of blood drop pattern analysis on soil, coaltaar, and footpath (cemented block) surfaces were considered. Scientific stand, dropper, measuring scale, pin, thread, protector and discarded blood were used for the purpose of observation. To determine the accuracy of measuring length and width of 2 individual blood drop for the purpose of estimation of angle. The parameters in this study were measured expected angle from 15.75^0 to 77.75^0 in relation to height from 15 cm to 120 cm. The outputs from the calculated angles are marginally acceptable with approximately 10% error. For the study of shape of bloodstains, diameter of blood drops between 0.7 cm to 1.4 cm in diameter.*

Keyword*: Blood drop pattern soil, Coaltaar, footpath, angle of impact, shape, approximately.*

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I. Introduction

Blood is one of the expressing and generally undergoes types of physical clue associated with the forensic examination of death and violent scene of crime. The establishment and egocentrism of human blood stains have continue over the ago 100 years since the ABO group system was identify by Landsteiner in 1901. The executions for the egocentrism of human blood in forensic science calculate on the ABO system for lifetime. The advancement of the impersonation of the red cell isoenzymes and serum genetic markers in the late 1970s carelessly increased the egocentrism of human blood. One of the important evidences in a crime scene is the bloodstain, which gives vital information about the incident, i.e. where the incident occurred. The stains of blood droplets provide the direction from the origin and an advantage of the bloodstains analysis is that the method for calculating the impact angle is the same regardless of the force acting upon the blood source **(Eckert *et al.*, 1999)**. The shapes of the stains vary from circle to oval depending on the impact angles from 90^0 to less than 90^0.

II. Methodology

The discarded sample of blood which was left after the analysis was collected from the pathology centre.

2.1 Procedure for Study of Drop Pattern :- Created the blood drop from known height Firstly, cleaned the different surfaces such as soil, Coaltaar, and footpath (cemented block) and removed the unwanted material like stone, grass, dry leafs etc. Filled a dropper with blood sample. Then dropper was gently squeezed a single blood drop so the stage blood falls freely, without any force except gravity acting on it. Measured the diameter of each blood drop in cm, using measuring scale. Repeated these steps for each of the 2 samples blood drop from 15cm to 120 cm in height. Calculated the average diameter of the drop that fall from different heights. At the last, photographed was clicked and observed for further analysis.

2.2 Procedure for Determining of Angle of Blood Drop: - Created the blood drop from known height from different surfaces. In this activity, cleaned the surfaces and removed the unwanted materials like stone, grass, and dry leaf. Scientific stand was kept on a place from different surfaces. Mounted a dropper perpendicular to the surfaces. The angles was then measured by placing a pin on the both ends of the blood drop and then ting one end of the thread on the pin and other end of the thread on the stand from where the drop was fallen from different heights. The protector was placed on the one end of the blood drop of the pin at 90^0 and then angle of that pin point was noted down. Same procedure was applied on the other end of the blood drop and the angle

was noted down. Use the following formula to determine the angle of blood spatter Calculation:-

$$\text{angle } (\sin\theta) = \frac{\text{Width (w)}}{\text{Length(l)}}$$

$$\text{Therefore:} \quad \theta = \sin^{-1}(w/l)$$

Calculate the % error between the known angle of blood spatter and calculated angle of blood spatter.

$$\% \text{ error} = \frac{\text{Value}_{\text{known}} - \text{Value}_{\text{calculated}}}{\text{Value}_{\text{known}}} \times 100$$

2.3 Chi-Square Test:- Observed characteristics were then statistically evaluated using the Chi-Square method. Chi-square is a statistical test used to compare observed data with data one would expect to obtain according to a specific hypothesis. This method is employed to know about the "goodness to fit" between the observed and expected values. It explains the deviations, i.e. differences between observed and expected, in between the result were due to chance or were they due to other factors. Chi-square test is purposefully used for scrutinizing the null hypothesis, which states that there is no significant difference between the expected and observed result. The Chi Square (x^2) test employed for the purpose is shown in Equation 1.

$$\boldsymbol{x2} = \sum_{i=o}^{n} = \frac{(Oi-Ei)2}{Ei} \ldots\ldots \text{Equation (1)}$$

2.4 Analysis of Variance (ANOVA): - Data collected on different surfaces and angle and to study the effect of surface on the angle of blood drop were tabulated for statistical analysis. Significance of difference between treatment means was tested through 'F' test and the critical difference (CD) was worked out wherever 'F' value was found to be significant for treatment effect.

III. Result And Discussion

In this study, measuring the angle and study of blood drop for the 8 blood drop pattern provided on each surfaces. Out of 24 samples of blood drop pattern, 8 samples of soil, 8 samples of Coaltaar, and 8 sample of footpath blood drop pattern were collected. After its examination following result were obtained which was given in the figures and tables below:-

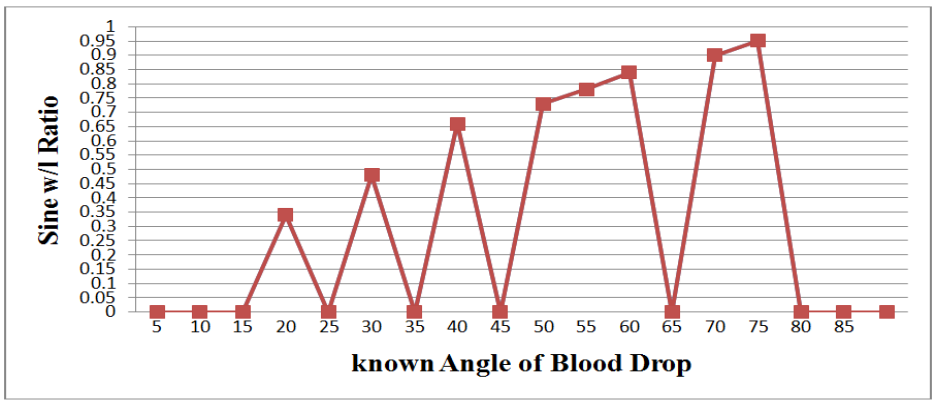


Fig 3.1 Relationship between Sine and the ratio of bloodstain widths divided by bloodstain length on footpath (cemented block) surface

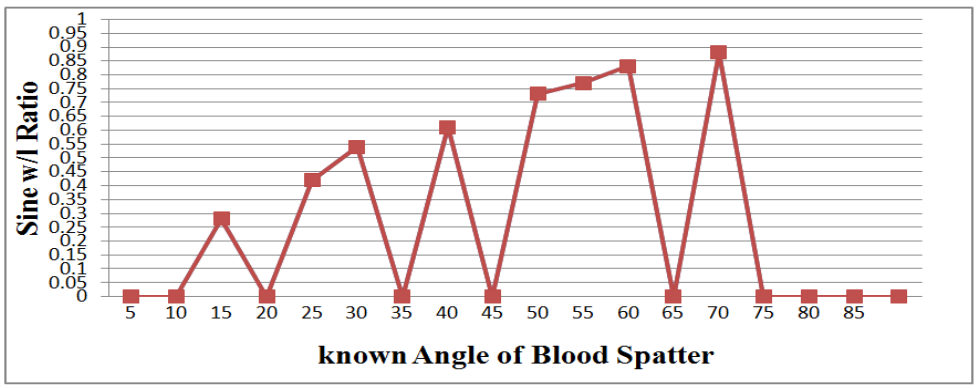


Fig 3.2 Relationship between Sine and the ratio of bloodstain widths divided by bloodstain length on soil surface

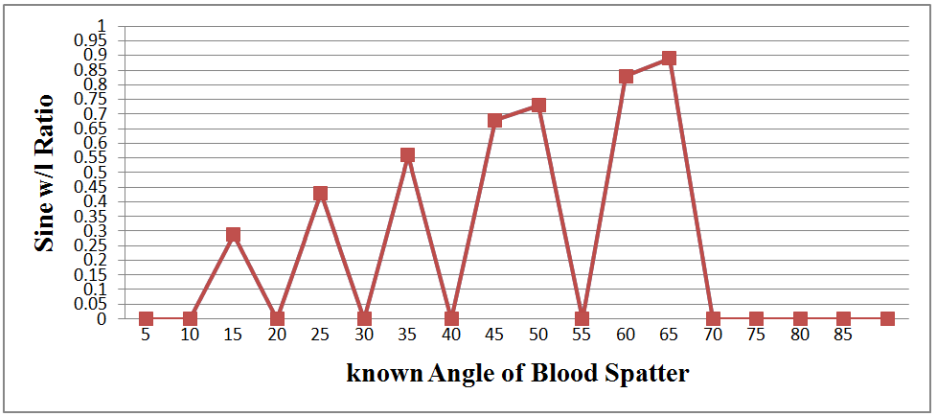


Fig 3.3 Relationship between Sine and the ratio of bloodstain widths divided by bloodstain length on coaltaar surface

IV. Results

As the table no 3.1 and figure no.3.1 clearly shows that on footpath surface at different known height and angle of length and width ratio both varies and the variance is linear.

Table 3.1 Blood Drop Pattern Measurement: Calculated angle values compared with known angle values in relation to height on footpath surface.

Known Height (cm)	Known angle	Length (cm)			Width (cm)			Average W/L (cm)	Arc sine W/L Average	Calculated Angle (Degrees)	% error Between Known and cal. Angle
		1ST Trial	2nd Trial	Average length (cm)	1st Trial	2nd Trial	Average Width (cm)				
15 cm	19^0	1.3	1.3	1.3	0.5	0.4	0.45	0.34	20.25	20.25^0	6.59%
30 cm	29.5^0	1.0	1.5	1.25	0.6	0.6	0.6	0.48	28.68	28.68^0	2.77%
45 cm	40.5^0	1.0	1.1	1.05	0.7	0.7	0.7	0.66	41.29	41.29^0	2.51%
60 cm	49.75^0	0.9	1.0	0.95	0.7	0.7	0.7	0.73	47.46	47.46^0	4.59%
75 cm	57.5^0	1.0	9.0	0.95	0.8	0.7	0.75	0.78	52.13	52.13^0	9.32%
90 cm	62.5^0	0.9	1.0	0.95	0.8	0.8	0.8	0.84	57.36	57.36^0	8.21%
105 cm	69^0	1.0	1.1	1.05	0.9	1.0	0.95	0.90	64.79	64.79^0	6.09%
120 cm	77.5^0	1.2	1.0	1.1	1.0	1.1	1.05	0.95	72.65	72.65^0	6.25%

As the table no 3.2 and figure no.3.2 clearly shows that on footpath surface at different known height and angle of length and width ratio both varies and the variance is linear.

Table 3.2 Blood Drop Pattern Measurement: Calculated angle values compared with known angle values in relation to height on soil surface.

Known Height (cm)	Known angle	Length (cm)			Width (cm)			Average W/L (cm)	Arc sine W/L Average	Calculated Angle (Degrees)	% error Between Known and cal. Angle
		1ST Trial	2nd Trial	Average length (cm)	1st Trial	2nd Trial	Average Width (cm)				
15 cm	15.75^0	1.3	1.5	1.4	0.4	0.4	0.4	0.28	16.60	16.60^0	5.39%
30 cm	24^0	1.0	1.1	1.05	0.5	0.4	0.45	0.42	24.83	24.83^0	3.45%
45 cm	32^0	1.2	1.2	1.2	0.7	0.6	0.65	0.54	32.68	32.68^0	2.12%
60 cm	40.5^0	1.0	1.1	1.0	0.7	0.7	0.65	0.61	38.24	38.24^0	5.58%
75 cm	49^0	0.9	1.0	0.95	0.7	0.7	0.7	0.73	47.46	47.46^0	3.14%
90 cm	57^0	0.8	1.0	0.9	0.7	0.7	0.7	0.77	51.05	51.05^0	10.05%
105 cm	61.05^0	1.0	0.8	0.9	0.9	0.6	0.75	0.83	56.44	56.44^0	7.84%
120 cm	67.75^0	1.0	0.8	0.9	0.9	0.7	0.8	0.88	62.73	62.73^0	7.40%

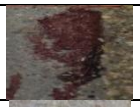
As the table no 3.3 and figure no.3.3 clearly shows that on footpath surface at different known height and angle of length and width ratio both varies and the variance is linear.

Table 3.3 Blood Drop Pattern Measurement: Calculated angle values compared with known angle values in relation to height on Coaltaar surface.

Known Height (cm)	Known angle	Length (cm)			Width (cm)			Average W/L (cm)	Arc sine W/L Average	Calculated Angle (Degrees)	% error Between Known and cal. Angle
		1ST Trial	2nd Trial	Average length (cm)	1st Trial	2nd Trial	Average Width (cm)				
15 cm	17.5^0	1.2	1.5	1.35	0.4	0.4	0.4	0.29	17.23	17.23^0	1.51%
30 cm	27^0	1.0	1.3	1.15	0.5	0.5	0.45	0.43	25.77	25.77^0	4.55%
45 cm	36.25^0	1.2	1.1	1.15	0.7	0.6	0.65	0.56	34.41	34.41^0	5.05%
60 cm	42.5^0	1.0	0.9	0.95	0.7	0.6	0.65	0.68	43.17	43.17^0	1.58%
75 cm	49.5^0	0.9	1.0	0.95	0.7	0.7	0.7	0.73	47.46	47.46^0	4.11%
90 cm	59^0	0.8	1.0	0.9	0.7	0.8	0.75	0.83	56.09	56.09^0	4.91%
105 cm	67.75^0	1.0	0.9	0.95	0.9	0.8	0.85	0.89	63.47	63.47^0	6.31%
120 cm	73^0	1.1	1.3	1.2	1.0	1.2	1.1	0.91	66.44	66.44^0	8.98%

As the table no. 3.4 shows that the on footpath surface, the 2 trials of blood drop for each height tested for a total of 16 trials. The drop began to take on elliptical to spherical shape.

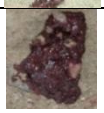
Table No. 3.4 The effect of footpath surface on the diameter and shape of blood drop

Height of drop (cm)	Diameter of drop (cm)		Average Diameter (cm)	Shape and observation of bloodstain
	Trial 1	Trial 2		
15 cm	0.8	0.6	0.7	
30 cm	0.9	0.7	0.8	
45 cm	0.8	1.0	0.9	
60 cm	1.0	0.9	0.95	
75 cm	0.9	1.0	0.95	
90 cm	1.0	1.1	1.05	
105 cm	1.0	1.5	1.25	
120 cm	1.3	1.3	1.3	

As the table no. 3.5 on soil surface, the 2 trials of blood drop for each height tested for a total of 16 trials. The shape of blood drop on soil surface was not distinguishable.

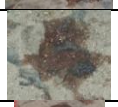
Table No.3.5 The effect of soil surface on the diameter and shape of blood drop

Height of drop (cm)	Diameter of drop (cm)		Average Diameter (cm)	Shape and observation of bloodstain
	Trial 1	Trial 2		
15 cm	0.9	0.7	0.8	
30 cm	0.7	1.0	0.85	

45 cm	0.8	1.0	0.9	
60 cm	1.0	0.9	0.95	
75 cm	0.9	1.1	1.0	
90 cm	1.2	1.2	1.2	
105 cm	1.0	1.1	1.05	
120 cm	1.3	1.5	1.4	

As the table no. 3.5 on soil surface, the 2 trials of blood drop for each height tested for a total of 16 trials. The shape of blood drop on soil surface was not distinguishable.

Table No.3.6 The effect of coaltaar surface on the diameter and shape of blood drop

Height of drop (cm)	Diameter of drop (cm)		Average Diameter (cm)	Shape and observation of bloodstain
	Trial 1	Trial 2		
15 cm	0.8	0.6	0.7	
30 cm	0.8	0.7	0.75	
45 cm	0.9	1.0	0.95	
60 cm	0.9	1.1	1.0	
75 cm	1.0	1.1	1.05	
90 cm	1.0	1.3	1.15	
105 cm	1.1	1.3	1.2	
120 cm	1.2	1.5	1.35	

STATISTICAL SIGNIFICANCE

Table No. 3.7 Chi Square Distribution to study between heights vs. angle of blood drop

Category	Chi square Value	Degree of Freedom (d.f.)	Tabulated Value	Result S/NS
Soil	43.30	7	14.06	S
Footpath	45.40			S
Coaltaar	49.30			S

- S= Significant
- NS= Non- Significant

The calculated Chi Square value for the considered soil surface was 43.30, for footpath surface the value was 45.40, and for coaltaar surface the value was 49.30 and at degree of freedom 7 and 5% level of

significance this values is greater than the tabulated value hence, the null hypothesis is rejected accepting the alternate hypothesis that height has a significant effect on the angle pattern of blood drop. Therefore it is a significant result. The analysis of chi square value for all the data have been given in appendix at the end.

Table No. 3.8 ANOVA distribution to study between the surfaces vs. angle of blood drop

Source	d.f.	S.S.	M.S.S.	F.Cal.	F. Tab 5%	Result	S.Ed.(±)	C.D. at 5%
Due to angle	(3-1) 2	187.083	93.541	32.736195	3.74	S	1.380	2.849
Due to surface	(8-1) 7	6111.134	873.019	305.52636	2.76	S	1.380	2.849
Error	14	40.004	2.857	-	-	-	-	-
Total	23	-	-	-	-	-	-	-

The calculated ANOVA value for the considered experiment at degree of freedom (3-1) 2, (8-1) 7 i.e. F.Cal.value, is greater than F.Tab value hence, the null hypothesis is rejected accepting the alternate hypothesis that there is a significant difference among the angles of blood drop with respect to height on different surfaces.

V. Discussion

The present study was aimed for the determination of shape and angle of blood drop pattern in relation to height on different surfaces. In present study, a total number of 24 blood drop sample were included. The surfaces which were considered in the study were soil, coaltaar, and footpath. The blood drop on different surfaces were measured for its width, length, and diameter and reported. After the measurement of every blood drop sample further examination and statistical analysis were performed. In this study, three different surfaces viz. soil, footpath, and coaltaar were studied , which were in addition to the previous work of **(Boonkhong *et al.*, 2010; Willis et al., 2001).** However, the results of this study are statistically significant and are according with the previous research in the field.

VI. Conclusion

The angles of 24 blood sample formed by blood drops viz. Soil, footpath, and coaltaar surfaces were determined using Straight Line Method and found signified differences in angle on different surfaces with respect to the height. The shapes of 24 blood drop samples (8 each sample) on selected surfaces viz. soil, coaltaar, and footpath were thoroughly analyzed and it is concluded that the shape ois clear and distinct in case of footpath surface, whereas it not distinguishable in case of soil and coaltaar. The observation of the experiment were statistically analyzed using Chi Square test for establishing relationship between height and angle and it was found significant as the calculated value at 5% level of significance is higher than the tabulated value which concludes that height has a significant effect on angle of blood drop. To study the significance of variation of angle on different surfaces Two Way ANOVA were employed and since the calculated F value was found greater than the tabulated F value, it is concluded that there is a significant variation as the formation of angle with respect to surfaces.

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