BLOODSTAIN VOLUME ESTIMATION

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Bloodstain pattern evidence can be used in a variety of ways in crime scene reconstruction. Careful examination and documentation of bloodstain evidence will often yield detailed information about the nature of such bloodstains and the causes of certain stains. This information can in turn provide valuable leads in solving crimes. For example, by studying the size and shape of bloodstains, the angle of incidence of these blood spots and the distance from the origin can be found. The origin of impact of blood spatters or falling bloodstains can be projected by examining the dynamics of blood droplets and the patterns they produce. The approximate velocity of causation of a group of blood spatters can be learned through the size, density and distribution of these blood spatters; the type and means of production of a bloodstain can be determined by analyzing the shape, appearance and pattern of such bloodstains. In addition, certain facts related to the crime scene can also be reconstructed through bloodstain evidence. For example, reconstruction of the geometric and spatial relationships between people and objects can be determined from the distribution and location of various bloodstains. The sequence of events may also be determined by studying the directional and geometric relationships of various bloodstains. The significance of these bloodstain patterns in criminal investigation have been well documented over the past 40 years (1-14). However, in reviewing the literature it was found that there has been very little discussion concerning the determination of the original volume of a dry bloodstain (16). This type of determination can be important in crime scene reconstruction. The volume of bloodstains can yield information about the following issues:

(1) in determining whether a particular scene is a primary crime scene or a secondary crime scene;
(2) in proving or disproving a suspect's alibi;
(3) in confirming or dismissing a witnesses statement;
(4) in determining the force with which a group of blood spatters was produced;

(5) in determining whether or not the amount of blood is consistent with a type of injury.

The following are some of the methods used by the Connecticut State Police Forensic Science Laboratory for the estimation of the original volume of a dry bloodstain. These methods have been applied in several major case investigations and the results have shown it to be very useful in case reconstruction. Both direct and indirect procedures can be used for estimating the volume of a bloodstain. The selection of a procedure largely depends upon the type, nature and texture of the surface on which the bloodstain is deposited.

A known volume of liquid blood was weighed with three different analytical balances. We have found this weight to be relatively constant. The dry weight of the blood was obtained by weighing the thoroughly dried blood crust on the same three analytical balances. Table 1 is a typical set of experimental data, showing the relationship between the dry weight and wet weight of a known volume of blood.

TABLE 1

VOLUME vs WEIGHT

VOLUME	WET WEIGHT	DRY WEIGHT	W-D mg.	mg./ul
0.01 ml.	10.4 mg.	2.3 mg.	8.1	2.3
0.02 ml.	20.5 mg.	4.8 mg.	15.7	2.4
0.04 ml.	40.2 mg.	9.6 mg.	30.6	2.4
0.05 ml.	51.6 mg.	12.1 mg.	39.5	2.4
0.06 ml.	61.4 mg.	14.1 mg.	47.3	2.4
0.08 ml.	81.8 mg.	19.7 mg.	62.1	2.4
0.10 ml.	101.8 mg.	24.1 mg.	77.7	2.4
0.20 ml.	203.9 mg.	46.0 mg.	155.9	2.4
0.40 ml.	408.1 mg.	96.1 mg.	312.0	2.4
0.50 ml.	503.5 mg.	122.4 mg.	381.1	2.4
1.00 ml.	1024.3 mg.	241.3 mg.	783.0	2.4

A plot of the data in table 1 showed the linear relationship between the dry weight of blood and their original volume.

Specifically the slope of the dry weight vs. volume plot was found to be 4.167 ml/0.1 mg or 0.4167 ml/mg. This value, termed the dry-blood constant, also held true for blood samplesdonated by different individuals of different sexes, races, and ages. By using this constant in a simple mathematical relationship, the original volume of bloodstains can be obtained by simply multiplying the dry weight of blood crust with the dry-blood constant (0.4167 ml/mg). These types of calculations will yield a rough estimation of the original volume of a bloodstain and avoid the more complex calculations involving densities.

All blood used for this study was of human origin. Fresh samples were donated by normal, healthy individuals. Some of the blood samples used contained EDTA, an anti-clotting agent. We have compared blood containing EDTA or heparin to freshly drawn blood without heparin and have not found them to be significantly different with respect to their weight. Table 2 shows the weight of 0.04 ml of fresh blood from four different donors. The results indicate that the relationship between the dry weight and wet weight of a known volume blood is a constant.

TABLE 2

VOLUME vs WEIGHT

0.04 ml of Blood (fresh) from Four Different Donors

DONOR	WET WEIGHT	DRY WEIGHT	Ww - WD	mg
HCL	0.03651	0.00928	0.02723	9.3
HCL	0.04089	0.00992	0.03097	9.9
HCL	0.03741	0.00940	0.02801	9.4
REG	0.04092	0.00867	0.03225	8.7
REG	0.04030	0.00910	0.03120	9.1
REG	0.04035	0.00925	0.03110	9.3
JCR	0.03651	0.00928	0.02723	9.3
JCR	0.03780	0.00890	0.02840	8.9
JCR	0.03841	0.00941	0.02900	9.4
MSL	0.03752	0.00924	0.02826	9.2
MSL	0.04019	0.00967	0.03052	9.7
MSL	0.03957	0.00943	0.03014	9.4

In addition, we have compared the weighing results from different examiners and we did find there are minor differences in weighing due to variations in the scale readings. However, we have not found the dry-blood constant to be significantly altered by these variations. The details are described as follows:

I. Direct Method

A. Direct method for bloodstain on a non-absorbent surface.

The original volume of bloodstains found on non-

absorbent surfaces such as knife blades, broken glass, metal objects, rocks, floor tiles, ceramic surfaces, plastic or finished hardwood. can be easily determined by a simple weighing procedure.

(1) carefully scrape or lift the bloodcrust from its surface;
(2) weigh the bloodcrust;
(3) original volume = weight x 0.4167 ml/mg.

The original volume of a bloodstain is equal to the weight of the bloodcrust times the drying constant. This constant has been determined by numerous experiments conducted over the years, following the previously outlined method, (11,12). The wet weight of 1 ml liquid blood was found to be 10.2 mg. The dry weight of 1 ml blood was found to be 2.4 mg. The weight lost during the drying process is 7.8 mg.

B. Direct Method for Bloodstain on an Absorbent Surface.

When blood is deposited on an absorbent surface such as paper, cloth, textile, soil, etc. it is impossible to recover all of the dried bloodcrust from the matrix since the blood has been absorbed into the matrix. Under these conditions the original volume of blood can be estimated with the following procedure:

(1) weigh the bloodstain with the matrix (Wb);
(2) weigh a same sized sample of the blank matrix (Wm);
(3) weight of the bloodcrust = Wb - Wm;
(4) volume of blood = (Wb x 0.4167 ml/mg).

Occasionally direct weighing methods are not feasible due to

circumstances. Two indirect methods can be used to estimate the original volume of blood.

II. Indirect Methods

A. Indirect Overlay Conversion.

When a large bloodstain is found on a large absorbent object such as a blanket, quilt, bedsheet, coat or carpet, the volume can be estimated by indirectly weighing a unit of the bloodstain according the the following procedures.

1. Prepare a ruled overlay.
2. Place the overlay over the bloodstain.
3. Count the numbers of units over the stain.
4. Weigh 1 unit of bloodstain (Wb).
5. Weigh 1 unit of blank surface (Ws).
6. UW (unit weight of blood) = Wb - Ws.
7. Total weight of blood
   (Tw) = number of units x UW.
8. Volume = TW x 0.4167 ml/mg.

B. Indirect Photo Weighing Method.

Occasionally the original bloodstain is not available for examination. The only available evidence are crime scene photos or crime scene notes and sketches. In several cases the volume of the original bloodstain became a crucial issue during the trial, making the estimation of the volume of the bloodstain a necessity. Although this procedure will not yield an accurate result, it will produce an acceptable estimate.

(1) cut out 1 unit area of the photo;

(2) weigh the unit area of photo (Wp);
(3) cut the bloodstained area from the photo;
(4) weigh the bloodstained area of the photo (Wb);
(5) total bloodstained area (TA) = Wb/Wp x unit area;
(6) obtain same type of blank surface material shown in photo;
(7) prepare 1 unit of blank surface material equivalent to the size of 1 unit area in photo;
(8) deposit liquid blood onto the unit area of blank surface;
(9) determine the volume of liquid blood used to deposit on the 1 unit blank surface (Vb);
(10) volume of original bloodstain = TA x Vb.

This procedure only will give a very rough estimation of the amount of blood in a particular stain. We have learned that both Professor Herb MacDonell and Ms. Anita K. Wonder have experience with this type of estimation. It appears that they are using similar methods, but with different procedures than what we have described. (13, 15)

In conclusion, the above methods can be used for estimation of the original volume of a bloodstain. However, these procedures should not be considered as techniques for accurate determination. These procedures for the estimation of original volume of a bloodstain are also subject to experimental errors. The condition of the bloodstain, the recovery rate of the bloodcrust and the weighing procedure are also important for the final determination. These procedures only provide the crime scene investigator with additional tools for crime scene reconstruction.

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