BLOODSTAIN VOLUME ESTIMATION

Henry C. Lee, Ph.D., M. E. Gessaman, Ph.D.,
and Elaine M. Pagliaro, N.B.

Connecticut State Police
Forensic Science Laboratory
and
University of New Haven

47
Blindspot pattern evidence can be used in a variety of ways in crime scene reconstruction. Careful examination and documentation of bloodspatter evidence will often yield detailed information about the nature of such bloodstains and the course of certain events. 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 bloodspots and the distance from the origin can be found. The origin of impact of blood spatters or falling bloodstains can be predicted by examining the orientation of blood spatters and the pattern they produce. The approximate velocity of trajectory of a group of blood spatters can be learned through the size, density and distribution of these bloodspatters. The type and means of projection of a bloodstain can be determined by examining the shape, appearance and pattern of such bloodstains. In addition, certain facts related to the crime scene can also be reconstructed through bloodspatter evidence. For example, the orientation of the geometrical and spatial relationship 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 relationship of various bloodstains. The significance of these bloodspatter patterns in criminal investigation has been well documented over the past 40 years [1-10]. 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 \((L)\). 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 was a primary crime scene or a secondary crime scene
2. In proving or disproving a suspect's alibi
3. In controlling or damaging an ax/wrench
4. In determining the force with which a group of blood spatters was propelled

A plot of the \(L\) between the 0.5
(3) 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. Each direct and indirect procedure 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 dried blood was weighed with three different analytical balances. We have found the weight to be relatively constant. The dry weight of the blood was obtained by subjecting the thoroughly dried blood stain to 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 stain.

<table>
<thead>
<tr>
<th>VOLUME</th>
<th>WET WEIGHT</th>
<th>DRY WEIGHT</th>
<th>W-D mg. mg/dl</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.01 ml</td>
<td>18.4 mg</td>
<td>5.3 mg</td>
<td>9.1  3.3</td>
</tr>
<tr>
<td>0.07 ml</td>
<td>35.5 mg</td>
<td>12.8 mg</td>
<td>22.7 2.0</td>
</tr>
<tr>
<td>0.26 ml</td>
<td>48.2 mg</td>
<td>32.7 mg</td>
<td>15.5 2.7</td>
</tr>
<tr>
<td>0.26 ml</td>
<td>51.6 mg</td>
<td>25.1 mg</td>
<td>26.5 3.4</td>
</tr>
<tr>
<td>0.46 ml</td>
<td>91.4 mg</td>
<td>54.1 mg</td>
<td>41.3 2.6</td>
</tr>
<tr>
<td>0.83 ml</td>
<td>163.8 mg</td>
<td>107.2 mg</td>
<td>56.6 2.2</td>
</tr>
<tr>
<td>0.19 ml</td>
<td>101.9 mg</td>
<td>54.1 mg</td>
<td>77.7 2.4</td>
</tr>
<tr>
<td>0.25 ml</td>
<td>125.9 mg</td>
<td>60.8 mg</td>
<td>51.9 5.4</td>
</tr>
<tr>
<td>0.26 ml</td>
<td>125.5 mg</td>
<td>58.1 mg</td>
<td>53.1 2.6</td>
</tr>
<tr>
<td>0.46 ml</td>
<td>126.5 mg</td>
<td>111.4 mg</td>
<td>133.0 2.4</td>
</tr>
<tr>
<td>0.83 ml</td>
<td>199.9 mg</td>
<td>189.3 mg</td>
<td>106.3 2.7</td>
</tr>
</tbody>
</table>

A plot of the data in Table 1 shows the linear relationship between the dry weight of blood and their original volume.
The dry weight of a volume of blood was found to be 0.14 ± 0.01 mg per 1.0 ml of blood. This value, termed the dry-blood constant, was obtained by determining the dry weight of blood from different individuals of different ages, races, and sexes. By using the constant in a definite mathematical relationship, the original volume of blood can be obtained by simply multiplying the dry weight of blood constant with the dry-blood constant (0.14 ± 0.01 mg/ml). These values of concentrations will yield a rough determination of the original volume of a bloodstream and avoid the more complex calculations involving variables. 

All blood used for this study was of human origin. Fresh samples were obtained by normal, healthy individuals. Some of the blood samples were obtained EDTA, an anti-coagulant agent. We have compared 100 ml 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 0.1 ml of fresh blood from five different donors. The results indicate that the relationship between the dry weight and wet weight of a known volume blood is consistent.

Table 2

<table>
<thead>
<tr>
<th>Donor</th>
<th>HCL</th>
<th>HCO3</th>
<th>HCO2</th>
<th>KO2</th>
<th>K2CO3</th>
<th>K2CO2</th>
<th>K2CO3</th>
<th>K2CO2</th>
<th>K2CO3</th>
<th>K2CO2</th>
<th>K2CO3</th>
<th>K2CO2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In addition to these different results in blood, the dry-blood constant was significantly different as follows:

5. Direct

A. Direct

The calculations...
### TABLE I

**VOLUME vs WEIGHT**

8.6 ml of Blood (RBCs) from Four Different Donors.

<table>
<thead>
<tr>
<th>DONOR</th>
<th>WET WEIGHT</th>
<th>DRY WEIGHT</th>
<th>W - WD</th>
<th>mg</th>
</tr>
</thead>
<tbody>
<tr>
<td>HCL</td>
<td>0.22051</td>
<td>0.00035</td>
<td>0.21223</td>
<td>0.5</td>
</tr>
<tr>
<td>HCL</td>
<td>0.22070</td>
<td>0.00075</td>
<td>0.21995</td>
<td>0.9</td>
</tr>
<tr>
<td>HCL</td>
<td>0.20464</td>
<td>0.00069</td>
<td>0.19865</td>
<td>0.4</td>
</tr>
<tr>
<td>KRO</td>
<td>0.24349</td>
<td>0.00269</td>
<td>0.24080</td>
<td>0.7</td>
</tr>
<tr>
<td>KRO</td>
<td>0.24830</td>
<td>0.00010</td>
<td>0.24820</td>
<td>0.1</td>
</tr>
<tr>
<td>KRO</td>
<td>0.24235</td>
<td>0.00025</td>
<td>0.24210</td>
<td>0.3</td>
</tr>
<tr>
<td>JCB</td>
<td>0.23031</td>
<td>0.00025</td>
<td>0.22973</td>
<td>0.2</td>
</tr>
<tr>
<td>JCC</td>
<td>0.23039</td>
<td>0.00020</td>
<td>0.22960</td>
<td>0.0</td>
</tr>
<tr>
<td>JCC</td>
<td>0.23061</td>
<td>0.00015</td>
<td>0.23046</td>
<td>0.4</td>
</tr>
<tr>
<td>MSL</td>
<td>0.23725</td>
<td>0.00014</td>
<td>0.23711</td>
<td>0.3</td>
</tr>
<tr>
<td>MSL</td>
<td>0.23720</td>
<td>0.00007</td>
<td>0.23713</td>
<td>0.3</td>
</tr>
<tr>
<td>MSL</td>
<td>0.23927</td>
<td>0.00033</td>
<td>0.23894</td>
<td>0.4</td>
</tr>
</tbody>
</table>

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

1. **Direct Method**
   
   A. Direct method for bloods of a non-absorbent surface.

The original volume of bloods of a non-
streamlines. Two indirect methods can be used to estimate the original volume of blood.

B. Indirect Methods

A. Indirect Overlay Convention

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

1. Prepare a ruled overlay.
2. Place the overlay over the bloodstain.
3. Count the number of units over the stain.
4. Weigh 1 unit of the stain (Wb).
5. Weigh 1 unit of blank surface (Wb).
6. UW (unit weight of blood) = Wb - Wa.
7. Total weight of blood
   \[ TW = \text{number of units} \times \text{UW}. \]
8. Volume = \( TW \times 5.015 \text{ ml/g} \).

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 becomes 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;
(1) weigh the unit area of photo with
(2) on the horizontal area from the photo
(3) weigh the horizontal area of the photo
(4) total horizontal area
(5) = weight of cell area
(6) divide the total area of the surface material above the
(7) prepare 1 unit of base surface material equivalent to the
(8) deposit liquid blood onto the unit area of base surface
(9) determine the weight of liquid blood used to deposit
(10) on the 1 unit blank surface (W)
(11) volume of original blood = W/A x 10

This procedure only will give a very rough indication of the
amount of blood in a particular stain. We have learned that
both Professor Sirks Macaulay and Mr. Cuthbert need have
experience with the type of estimation. It appears that they
are using similar methods, but with different procedures than
what we have described, (12, 13)

In conclusion, the above method can be used for estimation of
the original volume of a stain. However, these procedures
should not be considered as a substitute for accurate
determination. These procedures for the evaluation of original
volume of a stain are also subject to considerable errors.
The results of the experiments, the recovery rate of the
bloodstain, and the weighing procedures are also insufficient for
the final determination. These procedures may provide the
crime scene investigator with additional tools for crime scene
reconstruction.
REFERENCES


55