Blood Dynamics

In Motion and On Impact

22 April 1991

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Blood Dynamics

Learning Objectives

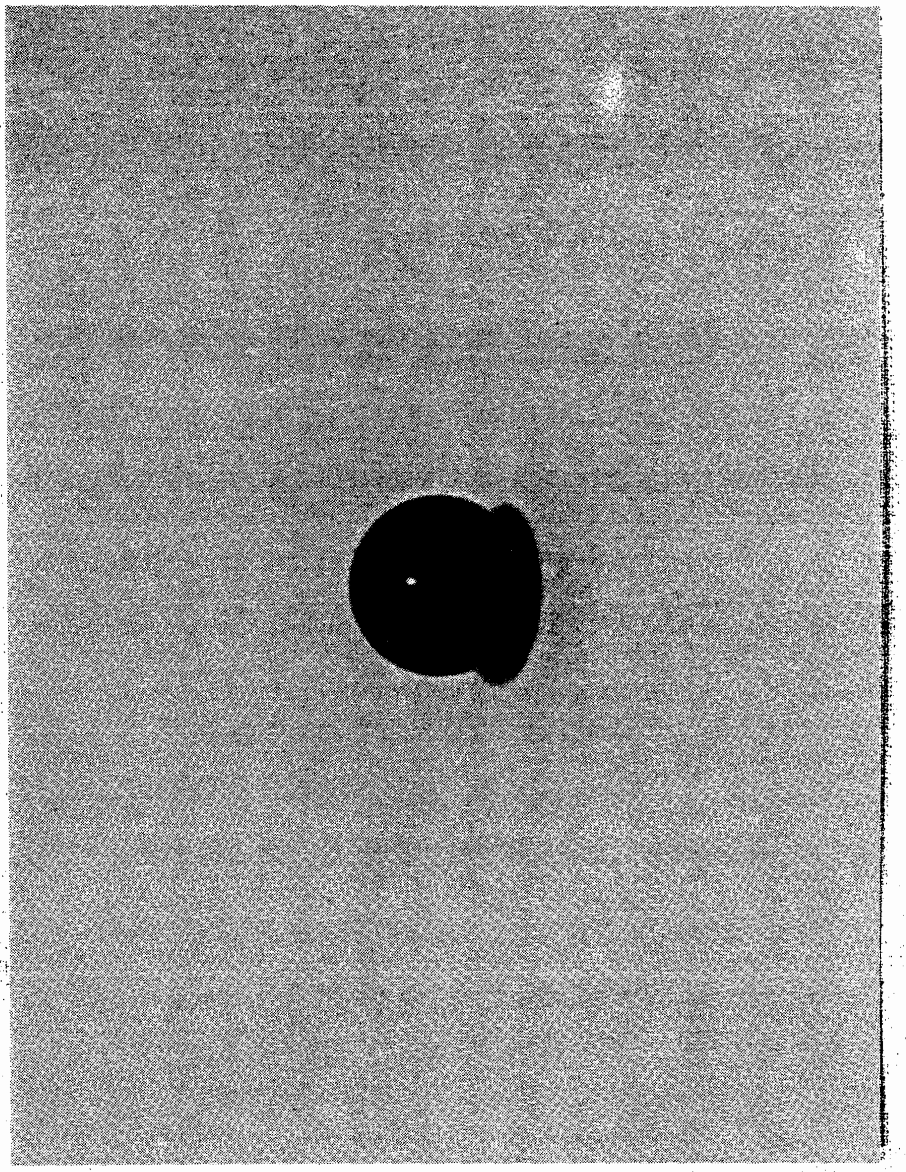
- Develop awareness of the physical properties of blood and their effect on the resulting spatter.
- Develop an understanding of the dynamic shifts blood under goes at impact.
- Develop an understanding of droplet formation at origination (low and medium velocity) and illustrate blood will seek an equilibrium while in flight.

Phases of Droplet Impacts

Contact/Collapse

- Characteristics:
  Spheroid collapses from the bottom upward. Blood volume from the collapsing sphere is forced outward to a rim.

- Development Factors:
  Angle of impact will determine the location of the developing rim.

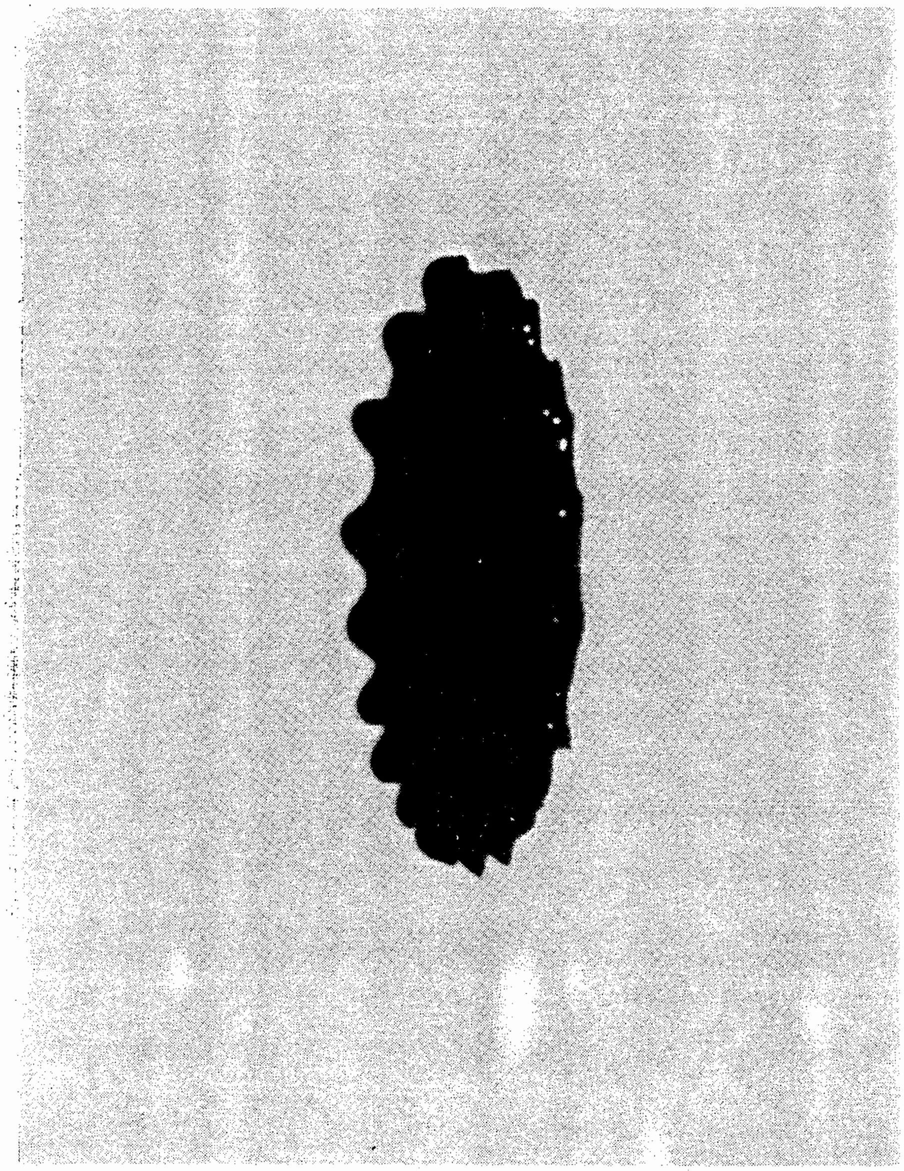


Phases of Droplet Impacts

Displacement

- Characteristics:
  Spheroid has collapsed. Blood volume has displaced to the perimeter rim. Surface tension has yet to be disrupted. Small dimples form on the perimeter as the volume is forced into this limited area. Dimples will cause much of the coronal effect seen in the subsequent stain.

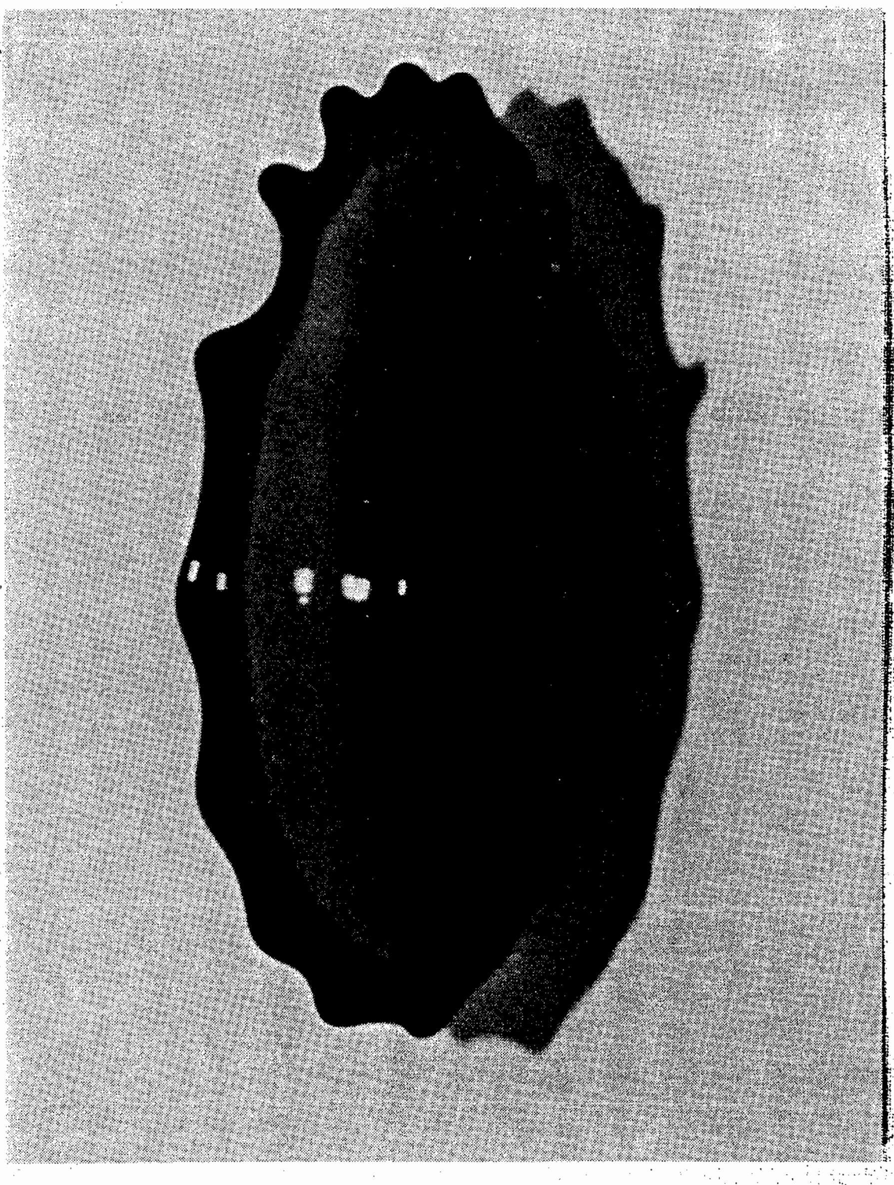
- Development Factors:
  Dropping height determines total area of displacement. Impact surface (particularly liquid to liquid) seems to increase the volume of blood present in the dimples.



Phases of Droplet Impacts
Dispersion

- Characteristics:
  Dimples continue to rise. A film of blood blossoms upward from the edges defined in the displacement phase. The majority of the remaining volume of blood is carried forward along the leading edge of the expanding rim. The blossoming effect travels upward and outward.

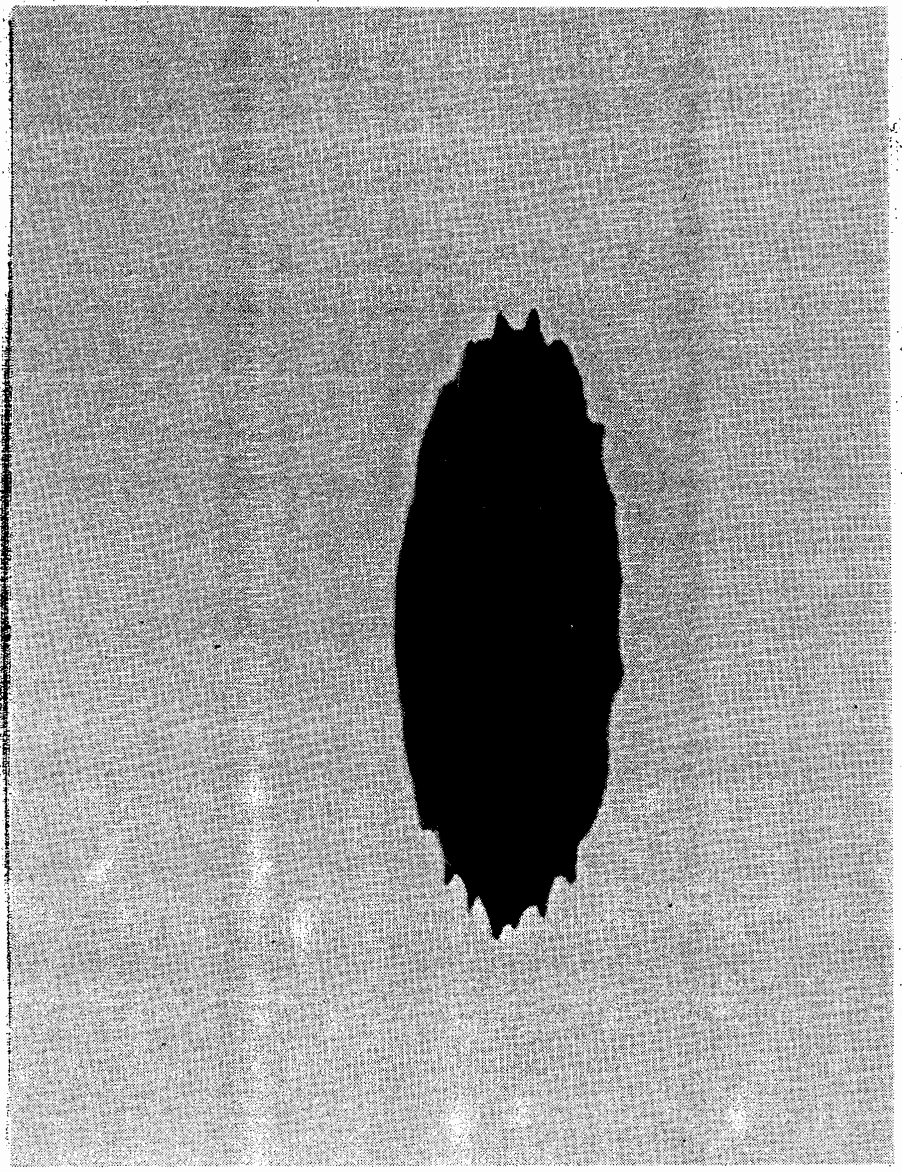
- Development Factors:
  Surface - hard surface full blossom effect; liquids the blossom rises less, dimples extend out on spine like filaments. Rough targets - surface tension is not broken but creates a greater adhesive force. The blossom rises less vertically and more outward.
  Distance fallen - amount of dimple dispersion.



Phases of Droplet Impacts
Retraction

- Characteristics:
  Depending upon surface characteristics dimples may detach, blossom regresses to its original position, developing a similar rim as seen in the displacement phase. Blood coalesces somewhat to refill the stain. A thicker rim will normally result.

- Development Factors:
  Liquid to liquid - more dimples, increased peripheral spatter.
  Wetting vs non-wetting surface - symmetry of the resulting stain.
  Porous surface - symmetry as a result of absorbency of target material. (weaves etc)



Objective #3

Understand Blood in Motion

- Observe droplet formations. (Mechanical and Natural)
- Observe that oscillation exist at the droplets origin.
- Observe the decrease of oscillations.
- Observe medium velocity blood at its origin.
- Observe the decrease in oscillation as time and distance increase.

Damping of Oscillations

Damping time is inversely proportional to the viscosity of the fluid.

Simplest form of oscillations (oblate/prolate) are the most important, since they take longest to damp.

Damping time is determined as follows:

$$T = 0.2\ D^2 / V$$

Where T = Time D= Droplet Diameter

Damping of Oscillations
Water vs Blood

Research in water indicates this formula may be applied as follows:

$$T(sec) = .5 D^2 (cm)$$

Since blood is 4 times as viscous a corresponding damping time would be .25 that of water.

For a 1mm droplet this time would be .05 for water and .012 for blood.

Oscillations are 87% damped for 2 time constants and 98% damped for 4 time constants.

Damping of Oscillations

Comparative Example

Given two samplings of droplets
5 mm and 1 mm in diameter.

Deficit Present In L vs W

36%
26%
12%

Time Constants Water (Blood)

$5 \cdot 5 \cdot .5 = 12.5 / 10 = 1.25$ (.312)

$1 \cdot 1 \cdot .5 = 0.5 / 10 = 0.05$ (.0125)

Damping of Oscillations

Comparative Example

Deficit	Time Constant(x2)	Distortion %	Actual Size
5 MM Droplet			
.36	.625	0.0465	0.234 mm
.26	.625	0.0338	0.169 mm
.12	.625	0.0156	0.078 mm
1 MM Droplet			
.36	.025	0.0465	.0465 mm
.26	.025	0.0338	.0338 mm
.12	.025	0.0156	.0156 mm

Time Constant X2 = 87% Damping of Original Distortion

Damping of Oscillations

Assumed 36% W/L Deficit

Droplet Size	Time Constant(x2)	Original	Remaining
1 mm	.025	.36 mm	0.0468 mm
2 mm	.1	.72 mm	0.0936 mm
3 mm	0.225	1.0 mm	0.1404 mm
4 mm	0.4	1.4 mm	0.18 mm