C1 Study on the Effects of Surface Roughness on Blood Patterns

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After attending this presentation, attendees will understand the feasibility of using a contact angle as a parameter to represent the surface characteristic at the blood impact velocity estimation.

This presentation will impact the forensic science community by introducing a new parameter capable of representing surface characteristic at the blood impact velocity estimation.

Blood impact velocity estimation plays an important role in crime scene reconstruction, and it is mainly studied by correlating the impact velocity to the number of spines radiating from the periphery of circular blood stains and the droplet volume. Paper, drywall, wood, etc. have been considered regarding the surfaces that blood impacts without introducing quantitative parameters that represent surface characteristics. This study focuses on the effects of the surface condition on the blood pattern by introducing the contact angle as a parameter to represent the surface.

The surface roughness of six stainless steel specimens used for blood impact tests was altered using a sand blasting process. The ten point roughness R_z of the specimens is 16.3µm, 17.5µm, 19.6µm, 24.5µm, 29.3µm, and 38.1µm. The contact angle of each specimen was measured by using a sessile drop method and maintaining blood temperature at 37°C. Maintaining the blood temperature at 37°C through a thermal bath, the viscosity of the test blood was measured with a cone plate type viscometer. The blood was dropped vertically by using a syringe with an adjusted droplet volume of 20µl. The syringe was mounted onto an adjustable laboratory stand to allow for variation in release height from 10cm to 100cm. A computerized fluid dynamic (CFD) analysis was performed to study the mechanism of spine formation by using the Flow-3D program, which finds the boundary of two phases by the volume of fluid (VOF) method. The surface of the specimens was scanned using an ATOS-III system. The scanned surface image of the specimen was used as a boundary wall in the CFD analysis to study the surface effects on the blood pattern.

The measurement results of blood viscosity showed the shear thinning characteristic of a non-Newtonian fluid; that is, the viscosity decreases as the shear rate increases. The results showed deviation in comparison with the results yielded by the viscosity model equations of Carreau and Kensey due to individual differences in the blood composition. Additional study is required to determine whether individual deviations of blood can be generalized by introducing multiple variables acquired by many blood samples including the results of bio-chemical analyses. The contact angle increased linearly as the roughness increased, and variation among the blood samples was also observed. The spread factor was calculated as the ratio of the stain and the droplet diameter and was represented as a Reynolds number. It increased as the Reynolds number increased but decreased as roughness increased. From these observations, it was concluded that roughness affects the contact angle and the spread factor through flow resistance. This tendency was more clearly pronounced when the momentum of the droplet was less. From the droplet impact experiments and the CFD analysis, the difference in the spread factor of specimen $R_z = 0$ µm with the other specimens becoming larger as the Reynolds number decreased. There was no spine formation for the specimen of $R_z = 0$ µm and $R_z = 17.5$ µm but with the specimen of $R_z = 38.1$ µm at the droplet release height of 0.5 m. As the release height increased, there was spine formation for the specimen of $R_z = 17.5$ µm but not with the specimen of $R_z = 0$ µm. In the case of the specimen of $R_z = 0$ µm, there was no spine formation throughout the range of release height. From these observations, it could be concluded that the spine formation depended on the droplet velocity as well as on the surface roughness. The contact angle can be an additional parameter to represent the droplet impact velocity together with the spine number and spread factor. Experiments to make a general equation to describe the blood impact velocity by introducing the parameter of the contact angle for various surfaces were prepared.

Blood Pattern, Contact Angle, VOF