suspended in cream or ice cream before being heated. All three strains suspended in water were inactivated by heating at 71.1°C for 15 seconds. When heated in cream the viruses withstood 79.5°C for 15 seconds and in ice cream they withstood 82.2°C for 25 seconds, with Y-SK resisting inactivation to the greatest extent.

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Effects of Plastic and Steel Surfaces on Clotting Time of Human Blood.* (21107)

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Studies in our laboratories using a mechanical heart pump(1) and intravascular prosthetic devices(2) have stimulated an investigation of the effects of various plastic and steel surfaces on the clotting of human blood. Only a few relatively limited comparative studies of surface effects on clotting have been reported previously(3-6).

Materials and methods. A method for the determination of clotting time on various types of surfaces was devised in which all observations were made by one individual. Materials studied were identically shaped into biconcave receptacles or open-end curved tubes with radii of ½ inch and 2 inches. Prior to each measurement, the surfaces under study were thoroughly cleaned with an alkali detergent, rinsed in distilled water, and oven dried. A plastic box with a removable transparent cover was suspended in a constant (37 ± 1°C) temperature water bath and continually rocked by a slow speed motor through an arc of 70° at a rate of 15 cycles per minute. Within the box, 2 test surfaces were placed simultaneously. Blood was obtained from normal individuals with no clotting defects. For each pair of determinations, 10 cc of blood were drawn from an antecubital vein, through a sharp 18-gauge needle into a siliconed syringe. Blood was drawn immediately after placement of a tourniquet, and samples were discarded if the vein was not immediately entered. Two cc of blood were then placed on each of the 2 surfaces to be tested and the first 6 cc drawn into the syringe were discarded. Thus, the blood tested contained a low tissue thromboplastin concentration(7). Time was measured with a stop-watch. Initially, 2 times were recorded; the onset of clot formation, and the time of completion of the clot. It was found

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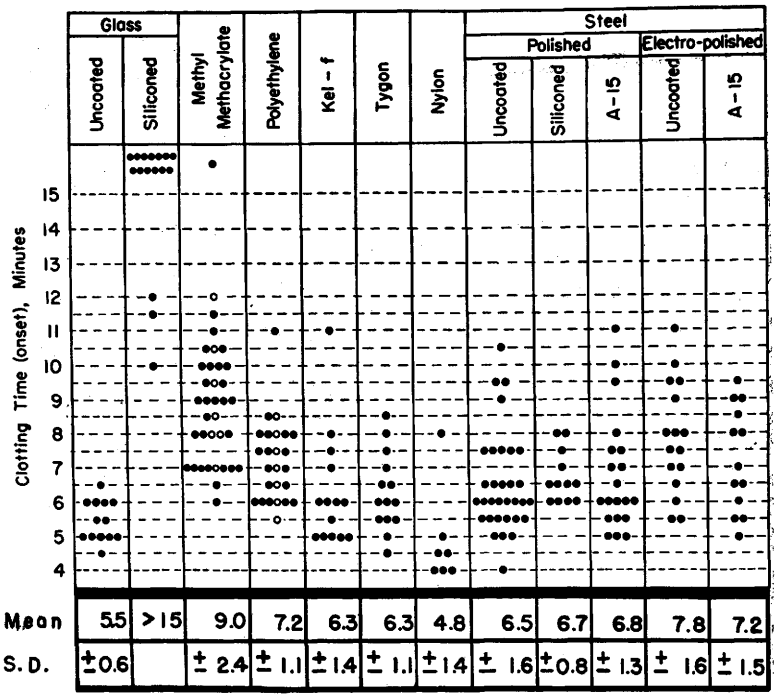

FIG. 1. Measured clotting times on the various surfaces, with means for each surface tested and standard deviations. Each point represents a single determination. Measurements made on surfaces soaked in water for 90 days are shown by the open circles and are not included in the calculations for mean and S. D.

that the onset of the clot had a more definite and reproducible endpoint, and this became the standard of measurement. The early clot was seen adhering to the surface of the test material in most instances, although in the cases of less "wettable" surfaces such as silicone, the earliest sign of a clot was a small dark floating fragment. If no clotting was noted in 15 minutes, the blood was poured on a tile surface and examined for evidence of clot formation. The materials studied are listed in Fig. 1. A-15 is a cationic nitrogen compound provided undiluted as follows: Tris (2-hydroxyethyl) dodecyl ammonium chloride, 5%; isopropyl alcohol, 40%; and distilled water, q.s. It was applied by boiling the alkali-cleaned steel test receptacle in a 10% solution for 15 minutes.

Results. The data are summarized in Fig. 1. Siliconed glass inhibited clot formation to a greater extent than any other material tested. Repeated determinations following one application of silicone revealed a rapid decline in this property. A second clotting time determination on a siliconed glass surface was not appreciably shorter than the first, but the third, fourth and fifth determinations revealed a rapid change in the surface effect. In these instances, the test surfaces were only saline rinsed between determinations. Fig. 1 includes only measurements made on the first application of silicone.

Methyl methacrylate exhibited a significantly greater clot inhibiting effect than other plastics, followed by polyethylene. Unsiliconed glass surfaces promoted clotting more readily than the polished No. 304 stainless steel surfaces. However, electropolished steel surfaces may have prolonged clotting times more than hand or machine polished steel surfaces. A-15 coated steel did not inhibit clotting further than uncoated steel. Clotting times on polished nylon (FM-3001) were shorter than those on glass or any other material tested.

Silicone applied to a steel surface did not

significantly alter its effects upon clotting time, but the appearance of blood placed on this surface was similar to that of blood placed on a siliconed glass surface in that a "repellant" effect was observed. Although there was a demonstrable decrease in the "wettability" of the surface or the adhesive force between the blood and the surface, clotting time was not altered. As in the case of collodion-lined glass tubes(8), the rule that the clotting time is inversely proportional to the "wettability" of the surface(9) did not hold.

Plastic materials absorb definite proportions of water on soaking for variable periods, but a small number of determinations performed on methyl methacrylate and polyethylene surfaces soaked in water for 90 days revealed no significant differences in mean clotting times. When a high polish was obtained on plastic or steel surfaces, additional polishing did not further prolong clotting times.

Fig. 1 shows that the distribution of observed clotting times for any one material tested was not symmetrical. The general direction of the spread was toward prolongation of the clotting time. We note this phenomenon to have occurred in another study similar to ours(6). It implies that the method of study was adequately controlled for factors causing premature clotting, but not for factors which might inhibit some process in the normal clotting mechanism.

Walter, Murphy, Jessiman, and Ahara(6) studied the clotting time of blood on No. 302 stainless steel surfaces treated with A-15 and a group of related compounds using a technic similar to ours. In their investigation, a significant clot retarding effect was noted on coated surfaces. Differences in the methods of study and analysis of data do not seem sufficient to explain the marked differences in the conclusions reached by these authors and ourselves.

The demonstration that a highly polished, uncoated stainless steel surface does not promote clotting more than glass led to preliminary trials of intravascular prostheses fabricated of stainless steel. A 2½" length of stainless steel tube, ⅜" I.D., highly polished, was substituted for a short segment of aorta in a dog, by the "multiple point fixation" method of Hufnagel(2). Examination of the prostheses and adjacent aorta after 3 weeks revealed no evidence of clot formation.

Summary. A standardized method for the measurement of clotting time on surfaces of different materials has been described. Several glass, plastic, and stainless steel surfaces, and surface coating agents, were studied for their comparative effects on the clotting of whole human blood. The results may provide an indication, with regard to clotting, of the suitability of these materials for use in the construction of blood systems and vascular prostheses.

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