excretion of urates (Table 1).

Chronic experiments on dogs thus showed that diodone and glucose do not affect each other's transport if the two are given together. No effect of these substances on the excretion of uric acid with the urine likewise was found. This indicates that combined administration of solution of diodone and glucose can be given in order to determine the maximal secretion of diodone, maximal reabsorption of glucose, and the excretion of urates all in the same experiment.

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HOMOCOAGULATION ON CONTACT OF BLOOD WITH POLYMER MATERIALS WITH ELECTRETIC PROPERTIES

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The behavior of hemocoagulation was studied on polymer materials with electretic properties. Negative polarity of the electretic polymers was shown to lead to fibrinogenemia and to hypoadhesion of the platelets compared with electretic materials of positive polarity and with polymers with no static electricity. It is considered that adsorption of fibrin and hyperadhesion of platelets play the principal role in thrombogenesis on implanted polymers.

KEY WORDS: *electretic polymers*; *hemocoagulation*; *platelets*.

Polymers are widely used in clinical and experimental medicine at the present time. The chief complications observed after implantation of polymers is thrombus formation on their surface [1, 4, 6, 11]. The thromboresistant properties of polymers are largely dependent on the character of the electrokinetic processes arising on contact between the polymers surface and moving blood [13-17]. There is evidence in the literature that polymers with a negative surface charge reduce adhesion of platelets on their surface [14, 16, 11].

Polymers which retain their surface charge for a long time in the absence of an electric field are electrets. In the course of time the surface charge of an electretic polymer can fall and its polarity be reversed. However, there are polymers which retain their electretic effect for a long time. The writers have obtained an electretic effect on polymer materials

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such as fluoroplast [polytetrafluoroethylene], silicon fluoride rubber, polycarbonate, polymethylmethacrylate, polyvinyl chloride, etc.

The behavior of hemocoagulation was studied during interaction between blood and electretic polymers.

EXPERIMENTAL METHOD

To study the effect of electretic polymers on hemocoagulation, polymer materials were molded into films, test tubes, and ordinary tubes. An electretic effect and polarization of the polymers were obtained by placing them in a powerful electric field and heating them at the same time. The charge on the film materials was measured by a compensation method, and on the tubes by means of a rising electrode (the incubation method). Blood for testing was taken from the femoral vein of the dogs and stabilized with sodium citrate in the ratio of 4:1. Blood was incubated in test tubes made of the electretic polymers for 1 h. The clock formation time [10], Quick's time for whole blood [3], the thromboelastogram, fibrinogen content, and blood heparin tolerance were investigated and the results recorded graphically on a coagulograph [12]; the free heparin concentration [7], index of platelet adhesion on polymer films [13], and spread of the platelets [9] were studied.

EXPERIMENTAL RESULTS AND DISCUSSION

The charge on the inner surface of a silicon fluoride rubber tube was $6.2 \cdot 10^{-8}$ C/cm^2. Tubes from the same polymer material also were obtained with a charge of $5.35 \cdot 10^{-8}$ C/cm^2. The polarity of the charge on the inner surface was negative. The blood clotting time in the silicon fluoride rubber tube with an electretic effect averaged 29 min 18 sec ± 42 sec. In the absence of an electretic effect (control), the blood clotting time was 16 min 12 sec ± 30 sec ($P < 0.01$). An increase in the negative surface charge of the silicon fluoride rubber caused a more marked increase in the blood clotting time. Meanwhile a positive surface charge caused a sharp decrease in the clotting time. In particular, a positive surface charge of $5.35 \cdot 10^{-8}$ C/cm^2 shortened the blood clotting time by 8 min 6 sec compared with the control ($P < 0.001$). The charge on the inner surface of fluoroplast test tubes was $1.2 \cdot 10^{-9}$ C/cm^2 for negative polarity and $1.55 \cdot 10^{-9}$ C/cm^2 for positive polarity. After incubation of blood with an electretic surface of positive polarity, the reaction time and clotting time of the blood were increased. There was marked decrease in the maximal amplitude of the thromboelastogram under these circumstances. By contrast with an electretic surface of positive polarity and a surface with no electretic properties, contact between blood and a surface of negative polarity caused no precise changes in the temporal parameters of the thromboelastogram (Fig. 1). This was shown by a comparative analysis of thromboelastograms recorded from blood immediately after its removal from the femoral vein. Blood cells and most of the plasma clotting factors are known to have a charge of negative polarity [2, 5, 8]. The hypocoagulation character of the thromboelastogram of blood after its contact with an electretic surface of positive polarity is thus due to adsorption of blood cells and of plasma clotting factors on the surface of the electret.

Quick's time after incubation of blood with an electretic surface of positive polarity was increased by 184 ± 27 sec compared with that after incubation with an electretic surface of negative polarity and by 83 ± 12 sec compared with the control. The quantity of fibrinogen in the test tube with an inner surface of positive polarity was 594 ± 43 mg %. In a test tube with an inner surface of negative polarity and in a fluoroplast test tube with no electretic properties the fibrinogen content was 228 ± 19 and 341 ± 22 mg % ($P < 0.01$). Contact between blood and an electretic surface of negative polarity was accompanied by a decrease in the blood heparin tolerance (Fig. 2). The free heparin concentration in the control fluoroplast test tube was 2.76 ± 0.4 mg %. On contact of blood with an electretic surface of negative polarity the free heparin concentration increased only very slightly. Meanwhile, after incubation of blood with an electretic surface of positive polarity the free heparin concentration was 3.34 ± 0.4 mg % ($P < 0.02$). On contact of blood with an electretic surface of positive polarity, the conversion of bound heparin into the free form was activated.

In a test tube with an inner surface of negative polarity the platelet count was 530,000 ± 43,000, whereas in tubes with a surface of positive polarity and in the control it was 210,000 ± 31,000 and 491,000 ± 39,000 respectively ($P < 0.05$). The platelet sedimentation rate was slowest in the test tubes with a negative electretic surface. Significant differences were obtained when platelet adhesion was investigated on electretic films of different polarity.

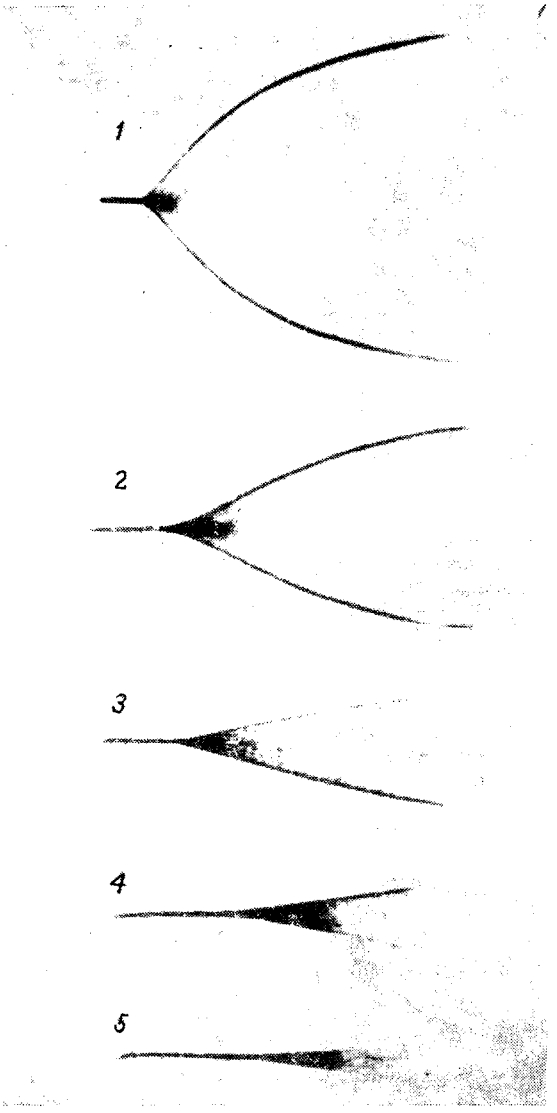

Fig. 1. Thromboelastograms of blood after incubation for 1 h with various polymers: 1) fluoroplast with negative surface charge; 2) silicon fluoride rubber; 3) polyethylene; 4) polymethylmethacrylate; 5) fluoroplast with positive surface charge.

The charge on electretic films made of fluoroplast was $1.7 \cdot 10^{-6}$ C/cm^2. The index of platelet adhesion on an electretic surface of negative polarity was 2 ± 0.4 ($P < 0.001$), whereas on an electretic surface of positive polarity it was 18.1 ± 1 ($P < 0.05$). On a control fluoroplast surface the platelet adhesion index was 8.7 ± 0.8. On an electretic surface with a positive surface charge, well marked platelet aggregation was observed; on an electretic surface of negative polarity the platelets preserved their shape and did not aggregate.

The results are evidence that surfaces possessing static electricity have a marked effect on hemocoagulation and on the functional properties of platelets. On contact of blood with an electretic surface of positive polarity hypocoagulation changes are observed in the blood and, at the same time, the fibrinogen concentration and platelet adhesion are increased. Meanwhile, contact of blood with an electretic surface of negative polarity was accompanied by a decrease in the fibrinogen concentration, by hypoadhesion of platelets, and by negligible changes in most of the blood clotting indices. It can be concluded from these findings that the chief mechanism of thrombogenesis on polymers is adsorption of fibrin on them and hyperadhesion of the platelets. The role of plasma blood clotting factors in thrombus formation on polymers is evidently unimportant. The results of these experiments showed that electretic polymers with a negative surface charge possess well-marked thromboresistant properties. This

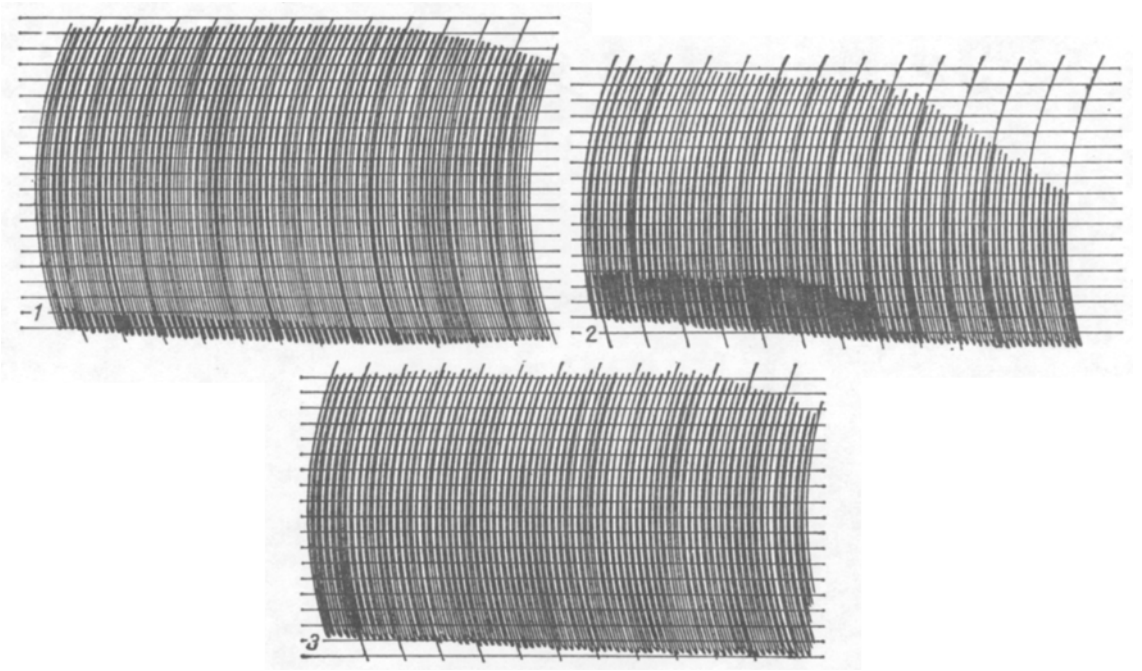

Fig. 2. Blood heparin tolerance on contact of blood with electretic materials (polycarbonate) of varied polarity: 1) control; 2) positive polarity; 3) negative polarity.

conclusion is confirmed by the results obtained after implantation of cylinders made of silicon fluoride rubber with an inner surface of negative polarity and after replacement of the femoral artery by a graft of this polymer material.

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