EFFECT OF EXTERNAL PRESSURE ON FOAM FORMATION AND STABILITY IN BIOLOGICAL FLUIDS

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The ability of biological fluids to form stable foam is due to the surface-active substances present in them in large quantities. This property is making itself increasingly frequently known in research in recent years. For example, depending on the degree of stability of foam obtained from amniotic fluid, a method of determining the probability of onset of a hyaline membrane syndrome in infants not yet born has been developed [1]. Observations on the rate of collapse of foam in edema fluid led to the discovery of the lung surfactant [3]. The ability of blood to create a stable foam must be taken into account when artificial circulation apparatuses are used [2]. The ability of biological fluids to form foam is thus one of their important properties, but one which has not yet found its due place in the current literature.

The object of this investigation was to study the connection between the basic properties of foam of biological fluids (foam generation, foam stability) and external pressure.

EXPERIMENTAL METHOD

Foam was obtained from blood plasma. For this purpose 3 ml of plasma was placed in a tube (volume 10 ml) which was closed with an airtight stopper. Through a hole in the stopper, an atmosphere of oxygen was created in the tube under raised or lowered pressure. The tubes were then transferred to a shaker, where they were agitated by harmonic oscillations with a frequency of 11 Hz and amplitude of 10 cm for 10 sec. Foam was thus obtained under different pressures. The tubes with foam were photographed. By comparing photographs taken at definite time intervals, conclusions were drawn regarding the rate of collapse of the foam under different conditions.

EXPERIMENTAL RESULTS

The investigations showed that the rate of destruction of foam was inversely dependent on external pressure: the lower the pressure, the higher the rate of destruction of the foam. The experimental relation-

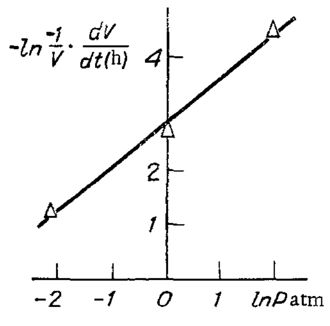

Fig. 1. Rate of destruction of foam as a function of external pressure. The relationship between the rate of foam destruction $(1/V)\cdot(dV/dt)$ and the reciprocal of pressure $1/P$ is linear.

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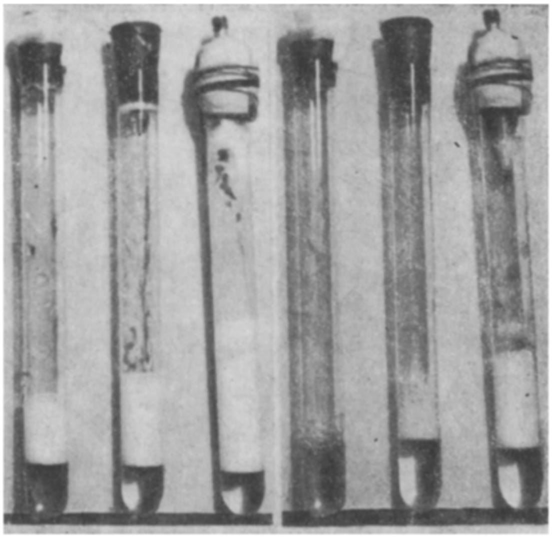

Fig. 2. Collapse of foam obtained from blood plasma. On left – foam after shaking, on right – the same foam 2 h later. Tubes arranged in order of increase of pressure (from left to right: 0.12, 1, and 7 atm).

ship between these two values is shown in Fig. 1. Tubes with foam obtained immediately after shaking are illustrated in Fig. 2. Characteristically, under high pressure ($P = 7$ atm) more foam was formed. After 2 h, destruction of the foam took place, and this process was most marked in the tube with lowest pressure ($P = 0.12$ atm).

The experiments thus showed that during shaking more foam is formed if the pressure is higher; destruction of foam takes place faster at a lower pressure. The first result is difficult at present to describe quantitatively. The second phenomenon can be explained on the assumption that foam of biological fluids collapses mainly because of the escape of gas through the wall of the bubbles under the influence of pressure, as determined by La Plas's equation. Calculations based on this assumption enabled the law of foam destruction to be expressed in the following form: $-(1/V)\cdot(dV/dt) = 1/P$, where V is the volume of the foam and P the external pressure.

As Fig. 1 shows, the experimental data are in good agreement with this equation. External pressure thus plays a decisive role in foam stability, and this is linked with the special mechanism of foam destruction in biological fluids – the escape of gas through the walls of the foam bubbles.

In conclusion, it should be noted that this phenomenon does not relate only to biological fluids, but also to others giving highly stable foam. The field of application of the law which has been discovered will therefore be wider than might at present be expected.

LITERATURE CITED

1. J. A. Clements et al., New Engl. J. Med., 286, 1077 (1972).
2. R. E. Pattle, Nature, 175, 1125 (1955).
3. P. F. Milnes and R. V. Woude, Surgery, 42, 986 (1957).