takes place over a wider area than in the case of erythroblasts, so that the electric charge on the membrane falls more sharply.

The change in the surface charge of the proliferating cells of the erythron after the action of the chalone is evidently a special kind of signal leading to subsequent intracellular changes in ionic composition and in nucleic acid synthesis, and ultimately to the delay of mitosis in the erythroid series, as was observed in the experiments now described.

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STATE OF THE LUNG SURFACTANT IN ANIMALS OF DIFFERENT SPECIES

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The activity of the lung surfactant in mice, rats, guinea pigs, hamsters, rabbits, and dogs was found to be within normal limits with variation of the coefficient of stability of the air bubbles between 0.84 and 0.93. Differences in the content of surfactant in animals of different species depend on the frequency, severity, and character of spontaneous pulmonary pathology. The data obtained can be used as the starting point for the study of the surfactant system of the lungs in various experimentally induced pathological states of the lung tissue.

KEY WORDS: lungs; surfactant; surface-active substance; type II pneumocytes.

During the last two decades the surfactant system of the lungs (SSL), which is responsible for maintaining the surface tension of the alveoli, has been studied. Numerous clinical and experimental investigations have shown that in several different pathological states of the respiratory organs the activity of the lung surfactant is modified, with the consequent development of atelectasis, an increase in the permeability of the air–blood barrier, and the development of pulmonary edema [2, 3, 5, 7, 10, 11, 13, 14]. Meanwhile the state of the surfactant of the lungs under normal conditions has been inadequately studied, although such initial data are essential for assessing the degree of damage to the SSL in pathological states of the respiratory organs. In a few investigations activity of the lung surfactant under normal conditions has been estimated mainly in only a single species of animal, and usually only one index, which was rarely compared with morphological changes in the lungs, was taken as the criterion [1, 3, 4, 12].

The object of this investigation was to make a combined study of SSL in animals of different species, including the estimation of surfactant by a quantitative method, identification of type II pneumocytes, which synthesize surfactant, and morphological analysis of the structure of the lungs.

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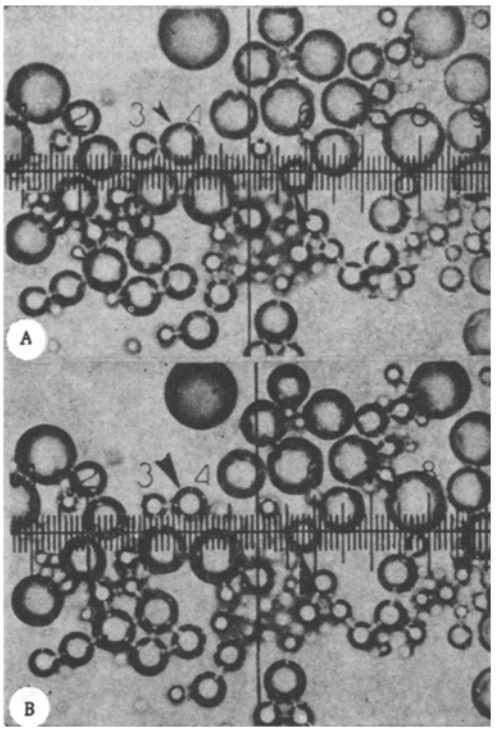

Fig. 1. Stability of air bubbles separated from mouse lungs.
A) Initial diameter of bubbles; B) diameter of bubbles after 20 min.

EXPERIMENTAL METHOD

The SSL was investigated in animals of six species: noninbred mice and rats, guinea pigs, golden hamsters, rabbits, and dogs. At least 10 animals of each species were studied. The mice, rats, guinea pigs, and hamsters were killed with ether, the rabbits by air embolism, and the dogs by electric shock. The state of the surfactant was assessed by Pattle's microscopic method [12], by determining the coefficient of stability of air bubbles isolated from the lungs (Fig. 1). Type II pneumocytes were detected by Berg's caffeine–benzpyrene method [6], based on the appearance of secondary fluorescence in ultraviolet light. The number of cell was counted in the ML-2A microscope (UFS-6-5 and BSF-2 entry filters, ZhS-3 suppressing filter) in 100 fields of vision in a total area of 1.2 mm^2, with a magnification of: ocular 5, objective 65 (water immersion). The morphological study of the lungs was carried out on paraffin sections stained with hematoxylin-eosin. The results were subjected to statistical analysis.

EXPERIMENTAL RESULTS

In mice, rats, guinea pigs, hamsters, rabbits, and dogs the coefficient of stability of air bubbles separated from the lungs was shown to vary from 0.84 to 0.93 (Table 1). The highest surfactant activity was found in mice, in which the coefficient of stability was close to unity (0.93). Rats, guinea pigs, rabbits, hamsters, and dogs have relatively low surfactant activity. Investigation of the type II pneumocytes in ultraviolet light showed that the number of these cells was approximately the same in mice, rats, guinea pigs, and rabbits, and it varied between 474 and 502 in 1.2 mm^2 (Table 1). Meanwhile, the number of type II pneumocytes in these animals differed significantly from the number of pneumocytes in the dogs and hamsters (Table 1). In dogs, for instance, their number was only one-quarter of that found in hamsters and one-third of that in the other species of animals. Conversely, in hamsters the number of pneumocytes was 1.5 times greater than in the other rodents.

In all the animals type II pneumocytes were located in the alveolar septa as separate cells, mainly oval in shape with an eccentric nucleus. Numerous large granules, giving whitish blue luminescence, were present in the cytoplasm, which occupied a large part of the cell (Fig. 2). Some pneumocytes containing small granules of yellow fat in their cytoplasm were observed. The accumulation of granules of this type also was found extracellularly in the alveolar septa.

TABLE 1. Some Indices of the State of the Surfactant System and Their Correlation with Lung Pathology (M ± m)

№	Species of animal	Number of animals	Coefficient of stability of air bubles	Significance of differences	Number of type II pneumocytes per area of 1.2 mm²	Significance of differences	Number of animals with lung pathology
1	Mouse	10	0,93±0,01		494,9±51,6	P_{1-5}, P_{1-6} <0,001	0
2	Rat	12	0,86±0,02	P_{1-2}, P_{1-3}, P_{1-5} <0,002	491,5±24,5	P_{2-5}, P_{2-6} <0,001	10
3	Guinea pig	10	0,84±0,03		502,6±30,4	P_{3-5}, P_{3-6} <0,001	9
4	Rabbit	10	0,85±0,05	P_{1-4} >0,05	474,5±30,1	P_{4-5}, P_{4-6} <0,001	6
5	Hamster	10	0,88±0,01		754,5±32,9	P_{5-6} <0,001	3
6	Dog	10	0,87±0,02	P_{1-6} <0,01	174,3±17,6		3

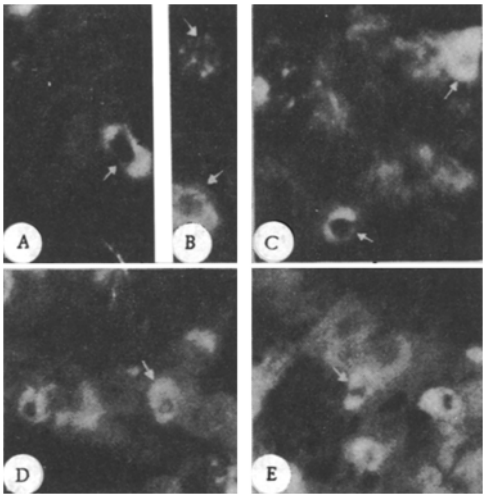

Fig. 2. Luminescent type II pneumocytes in lungs of rabbit (A), dog (B), mouse (C), hamster (D), and rat (E). Stained with 3,4-benzpyrene by Berg's method. Ocular homal, 3×; objective 65×, water immersion.

In all species of animals except mice, signs of acute or chronic inflammation were discovered in the lungs. Usually they were found as small or large foci of atelectasis, thickening of the alveolar septa, desquamation of the alveolar epithelium, focal pneumosclerosis, and foci of acute and chronic bronchopneumonia These changes were seen most often in rabbits, guinea pigs, and rats and less frequently in hamsters and dogs (Table 1).

Investigation of the lung surfactant in mice, rats, guinea pigs, rabbits, hamsters, and dogs thus showed that its activity in the animals of these species was within normal limits, corresponding to a coefficient of stability of 0.85-1, according to data in the literature [3]. Meanwhile, in some species of animals its content is different. There are indications in the literature that differences may exist in the SSL between animals of different species, although the reasons for these differences are not explained. For instance, Bracco and Curti [9] showed that the phospholipid fraction of the surfactant in rabbits accounts for 94.2% of the total lipid content, whereas in dogs and cows it accounts for 74% and in guinea pigs for 61%.

The study of activity of the lung surfactant by determining the coefficient of stability of air bubbles, combined with counting the number of type II pneumocytes which synthesize surfactant and with investigation of morphological changes in the lungs, showed that the differences in the surfactant content in animals of different species evidently depend on the frequency, severity, and character of the spontaneous pulmonary pathology. According to the results of morphological investigations, pathological changes were most frequently found in

the lungs of rats, guinea pigs, and rabbits, and it was in these species of animals that the activity of the pulmonary surfactant was lowest. In mice, with no signs of lung pathology, the surfactant content was highest (Table 1).

No correlation could be found between the coefficient of stability of air bubbles isolated from the lungs and the number of type II pneumocytes.

The fact that the lungs of dogs contain only one-third to one-quarter the number of type II pneumocytes found in animals of other species must evidently be regarded as a species-specific difference. This is confirmed by an investigation by Shishkin [8], who found a decrease in the number of large type II alveolar cells during the transition from rodents to carnivores. An increase in the number of type II pneumocytes in hamsters compared with other species of animals could perhaps be compensatory and connected with their mass death. This is confirmed by the presence of large numbers of type II pneumocytes with signs of fatty degeneration and of destruction of the cells in the lungs of the hamsters.

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