CHANGES IN SURFACTANT PROPERTIES OF THE LUNGS IN EDEMA

A. A. Akhmetov and I. A. Serebrovskaya

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The surface tension of lung tissue extracts of albino rats with pulmonary edema caused by poisoning with thiourea, adrenalin, or ammonium chloride or by the action of aconitine on the brain was significantly increased over that of the lungs of healthy animals. Meanwhile, the luminescence of the inner lining layer of the alveoli in ultraviolet light was simultaneously weakened.

Many workers have confirmed the role of a surfactant lining the alveoli in the respiratory mechanics of the lungs. The study of the surfactant in pulmonary edema has revealed disturbances of surface activity [2, 8-10, 12] and of the mechanical properties of their tissue [6], although in some cases no changes were found in these properties in edema [4, 5, 7].

In the experiments described below the surface tension of lung tissue extracts was investigated in four different models of pulmonary edema.

EXPERIMENTAL METHOD

A comparison was made of the surface tension of extracts from the lung tissues of 55 control adult albino rats and 57 experimental rats in which pulmonary edema had been induced by intraperitoneal injection of 1% thiourea solution (100 mg/kg) or 0.7% ammonium chloride solution (420 mg/kg) by intravenous injection of adrenalin (0.2 mg/kg), or intracisternal injection of aconitine hydrochloride in a dilution of 10^{-5} (0.06 ml). The presence and severity of edema were judged from the content of frothy fluid in the trachea and from the specific gravity of the lungs. The lung tissue extract was prepared by homogenization of the tissue with the addition of physiological saline in an amount equal to the weight of the tissue. When the extract was prepared from edematous tissue, allowance was made for the excess of fluid which it contained. The homogenate was centrifuged; 1 ml of supernatant was taken for testing. In these series of experiments the surface tension of the extracts of the healthy and edematous lungs was determined at 17°C by Rebinder's method [2], using for the calculation the formula

$$\frac{2P}{r}\text{ dyne/cm},$$

where P is the pressure at the moment the bubble bursts, r the radius of the outlet of the capillary tube. The mean of five to six measurements was taken for the calculation.

In the other series of experiments on 24 control rats and 20 animals in which pulmonary edema had been induced by adrenalin or thiourea the surface tension of the extracts was determined by the ring breaking method [1]. The extract was made up to a volume of 25 ml and transferred to a vessel 75 mm in diameter. Measurements were carried out at 20°C by means of a platinum ring 24.3 mm in diameter and

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TABLE 1. Surface Tension of Extracts of Normal Lung Tissue and in Certain Types of Pulmonary Edema (M±m)

Type of edema	Rebinder's method			Ring breaking method		
	No. of rats	Surface tension of extract (in dynes/cm)	P	No. of rats	Surface tension of extract (in dynes/cm)	P
Thiourea	23	64,56±1,23		10	47,65±0,53	
Control	21	58,26±1,18	<0,01	14	40,42±0,20	<0,001
Adrenalin	17	62,03±0,71		10	46,59±0,55	
Control	17	55,98±1,83	<0,01	10	40,28±0,18	<0,001
Centrogenic (aconitine)	11	62,00±0,52				
Control	11	56,13±0,35	<0,001			
Ammonium chloride	6	61,49±0,71				
Control	6	53,16±0,95	<0,001			

1-g torsion scales specially adapted for this purpose. After each of the five measurements the ring was washed with water, alcohol, and ether and carefully annealed. The surface tension was calculated by the formula

$$(P/4\pi r)F,$$

where P is the force required to break the ring, r the mean radius of the ring, and F a correcting factor.

In some control animals and in all forms of pulmonary edema the luminescence of the surfactant was studied in sections through the lungs and in the edema fluid by means of the MUF-3 microscope.

EXPERIMENTAL RESULTS AND DISCUSSION

The values of the surface tension obtained by Rebinder's method for normal lungs were higher than the maximal values given in most publications, determined by means of Wilhelmi's scales, although some workers obtained relatively high values by this method also, namely, 53-57 dynes/cm [7, 10]. The values obtained by the ring breaking method for extracts from normal lungs corresponded to the maximal values of surface tension given by most investigators, viz. 40-44 dynes/cm [3, 8, 9].

The results given in Table 1 show that in all forms of pulmonary edema the surface tension of the lung tissue extracts was significantly higher than in the control animals. This points to a decrease in surfactant activity in edema, lowering the surface tension. The decrease in the intensity of fluorescence of the inner lining of the alveoli, a disturbance of its continuity, and a decrease in the number of luminescent alveoli in edema correlated with the changes in surface tension of the extracts. The development of edema is accompanied by partial desquamation of the alveolar lining as stable vesicles [11]. The characteristic luminescence of these vesicles was observed in the edema fluid. However, its surface tension (67.6-68.3 dynes/cm) by Rebinder's method was virtually indistinguishable from the surface tension of the blood serum (67.1-68.0 dynes/cm) and was significantly higher than that of extracts from edematous lungs. One of the possible causes of the relatively low surface activity of the edema fluid could be the inactivating action of certain blood proteins on the surfactant [13].

Comparison of the surface tension of extracts of the lungs in mild thiourea edema (specific gravity of the lungs 0.90±0.006; 0.70±0.002 in the control) and in severe edema (specific gravity 1.40±0.17) revealed no significant difference between them: 63.28±1.41 and 65.72±1.05 dynes/cm, respectively ($P > 0.1$). This suggests that the phenomenon of transudation of fluid into the alveoli is not the only mechanism of disturbance of surface tension in the lungs.

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