SURFACE ACTIVITY OF EXTRACTS OF THE LUNGS AND OTHER ORGANS

É. V. Byul' and I. A. Serebrovskaya

UDC 612.215.3.015.21.014.462

Monomolecular surface films are formed at the liquid–air interphase boundary in saline extracts not only of the lungs, but also of other organs. During compression and stretching of these films on a Wilhelmy balance surface tension (ST) – area isotherms typical of solutions of surfactants were recorded. Similar curves with a minimal ST of less than 12 dynes/cm were obtained during tests on monolayers of surfactants deposited on a liquid underlay from a volatile solvent. Lung surfactants differed from those of other organs in their high ability to reduce ST during compression of the monolayer.

KEY WORDS: surface tension; surfactants; monomolecular layers; Wilhelmy balance.

The role of surface phenomena in various biological processes is extremely important [3]. However, the view is held in the literature that it is only lung surfactants that can reduce surface tension (ST) below 20-12 dynes/cm [5, 7]. Ganitkevich [4] has stated that extracts of many other tissues possess approximately the same surface-active properties but gave no quantitative data and did not describe the methods of his investigation. To study this problem an adequate experimental approach is required to the assessment of surface activity (SA) of the test substrate.

The object of this investigation was to compare SA of extracts of the lungs and other organs by various methods of determining surface tension (ST).

EXPERIMENTAL METHOD

The properties of surface films formed in tissue extracts at interphase boundaries as a result of adsorption were studied in two series of experiments (on rabbits and rats). The extracts were obtained by homogenization of the tissues in physiological saline (1 g tissue to 150 ml extract) and the cuvette of a surface tension balance described previously [1] was filled with them. After the establishment of adsorption equilibrium the static ST was measured and ST–area isotherms were recorded automatically during compression of the surface film from the original area of 60 cm^2 and its subsequent stretching back again to the initial area at a speed of 0.32 cm^2/sec. From the curves thus recorded the maximal and minimal values of ST were calculated and the index of stability [6] determined. In the experiments of series III monomolecular layers of surfactant were obtained by depositing the substance from a volatile solvent [5, 7, 8]. The tissue was minced in 30 volumes of physiological saline and centrifuged at 2,000 rpm for 5 min; 1 ml of the resulting supernatant was diluted with 2 ml isopropyl alcohol. The mixture was deposited drop by drop from a micropipet on an underlay consisting of physiological saline, filling the cuvette. Thanks to the isopropyl alcohol the surfactant was distributed at once over the surface of the underlay. Another advantage of this method is that only a very small quantity of surfactant is required. Taking the quantity of surfactant required to adjust ST to 40 dynes/cm [9], calculated per square centimeter, as the conventional unit its content was compared in these units per gram of the tissues tested.

Department of Pathological Physiology, Karaganda Medical Institute. (Presented by Academician of the Academy of Medical Sciences of the USSR P. D. Gorizontov.) Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 82, No. 10, pp. 1218-1220, October, 1976. Original article submitted March 12, 1976.

TABLE 1. Surface Activity of Saline Extracts of Various Organs of Rabbits and Rats (M ± m)

Tissue	Animals	Number of experiments	ST, dynes/cm			Index of stability
			static	maximal	minimal	
Bile	Rabbits	3	40,0±1,1	41,1±1,3	31,2±3,3	0,27±0,07
Brain	Rats	5	46,5±0,3	49,4±0,4	19,0±1,4	0,89±0,06
	Rabbits	3	48,4±0,0	51,0±0,5	22,2±0,7	0,79±0.02
Kidneys	Rats	5	44,7±0,7	47,4±0,5	18,0±0,7	0,90±0,02
	Rabbits	5	46,2±2,0	49,2±1,4	20,7±1,9	0,80±0,08
Liver	Rats	5	43,0±0,9	47,2±0,8	16,4±0,9	0,97±0,03
	Rabbits	5	42,6±3,0	47,4±1,6	19,0±1,4	0,86±0,06
Small intestine	Rats	5	31,9±1,3	36,0±0,9	16,4±0,7	0,71±0,06
	Rabbits	3	43,2±2,4	47,3±0,9	16,8±0,3	0,95±0,02
Spleen	Rats	5	48,5±0,5	50,5±0,7	22,9±1,1	0,77±0,03
	Rabbits	4	44,1±1,9	47,3±1,2	18,3±1,5	0,89±0,05
Pancreas	Rats	11	27,5±0,7	33,8±1,3	14,0±1,7	0,86±0,09
	Rabbits	4	24,9±0,6	31,2±0,6	5,9±0,3	1,36±0,03
Lungs	Rats	5	41,1±0,9	44,5±0,5	15,8±0,4	0,95±0,02
	Rabbits	20	43,6±0,5	51,2±0,3	9,7±0.1	1,37±0,05

EXPERIMENTAL RESULTS AND DISCUSSION

The results of the first two series of experiments are given in Table 1. Their analysis shows that aqueous extracts of all the test organs possessed the property of reducing ST of the solvent, characteristic of surfactant solutions, and of forming films on its surface, during compression and stretching of which ST–area curves with well-marked hysteresis are recorded. In rabbits, this property was seen most clearly in extracts of the lungs, pancreas, and small intestine. In rats extracts of the liver, lungs, brain, and kidneys possessed the greatest activity. It was discovered that a solution of rabbit's bile in saline had a low static ST, whereas the minimal ST was very high and the index of stability extremely low. On the other hand, the very low values of the static ST of extracts of the rat small intestine and rat and rabbit pancreas, and also the minimal ST on rat pancreatic extracts were not accompanied by an equivalent increase in the index of stability, as observed on a change in the surfactant concentration in solution [2]. This was evidently due primarily to qualitative differences in the surfactants forming the monolayer. Not only a difference in the quantity of surfactant per unit mass of tissue, but also qualitative differences in its nature, can cause differences in SA of the extracts of the homonymous tissues of rats and rabbits.

For each experiment of series III the parameters of three hysteresis loops are given in Table 2. The first of them was recorded after deposition of 24 drops of extract of surfactant, diluted with alcohol, on the underlay. Compression and stretching of the monolayer were carried out after deposition of each four drops of

TABLE 2. Surface Activity of Monolayers of Surfactants from Various Organs of Rats on an Underlay of 0.9% NaCl (M ± m)

Tissue	Number of experiments	ST, dynes/cm			Index of stability	Quantity of surfactant per gram tissue, conventional units
		static	maximal	minimal		
Brain	3	50,1±3,5	62,1±0,8	17,1±2,4	1,13±0,08	25 506±962
		23,6±1,3	53,6±0,9	7,5±0,4	1,51±0,03	
		40,0±0,0	61,6±0,2	12,1±1,8	1,34±0,08	
Kidneys	3	46,5±1,3	57,0±1,1	13,0±1,1	1,26±0,04	44 567±7 397
		23,4±1,1	51,3±0,4	10,9±3,7	1,31±0,18	
		40,6±0,0	55,0±1,3	13,0±1,8	1,24±0,07	
Liver	3	42,8±1,7	55,8±1,8	18,7±1,3	1,00±0,05	47 016±9 414
		23,3±0,4	53,6±0,5	15,2±1,1	1,12±0,05	
		40,2±0,5	58,9±0,9	15,6±0,4	1,16±0,01	
Small intestine	3	40,4±1,3	48,2±2,8	9,9±2,2	1,33±0,09	31 786±8 541
		24,1±1,7	43,0±3,5	9,0±0,7	1,31±0,004	
		40,4±0,3	51,8±4,4	16,8±3,9	1,03±0,15	
Spleen	3	47,8±0,7	57,0±0,6	11,8±0,7	1,13±0,04	45 639±3 464
		23,2±0,4	49,9±1,1	13,0±1,5	1,18±0,06	
		40,0±0,5	55,3±1,5	10,4±1,3	1,37±0,05	
Pancreas	3	31,2±1,1	47,8±2,6	13,3±0,6	1,13±0,004	60 777±4 604
		22,4±0,5	45,2±4,4	12,8±2,2	1,16±0,17	
		38,8±1,3	59,1±2,6	15,4±1,5	1,17±0,03	
Lungs	5	47,0±0,9	57,0±1,0	4,8±0,9	1,69±0,05	34 174±2 335
		22,5±0,5	48,3±0,9	3,2±2,0	1,77±0,14	
		40,2±0,2	53,5±0,7	9,5±2,1	1,41±0,12	

extract. The second loop was recorded after the static ST had been adjusted to the lowest possible value, and the third on establishment of the initial ST, roughly equal to 40 dynes/cm. The first fact that will be noted is that in all three cases the index of stability of the monolayers of lung surfactants were considerably higher than those for surfactants of other organs. Meanwhile, as regards their static ST and quantity of surfactant, the lungs were comparable to the other organs.

These results are of great importance. First, they demonstrate conclusively that, contrary to the views of some workers [5, 7], extracts of the brain, kidneys, small intestine, and spleen of rats and pancreas of rabbits can reduce ST during compression of the surface monolayer below 12 dynes/cm. On the other hand, they point to the high surface activity of lung surfactants, distinctly higher than the SA of extracts of other tissues.

LITERATURE CITED

1. É. V. Byul', Byull. Éksp. Biol. Med., No. 6, 118 (1975).
2. É. V. Byul', in: The Physiological Role of Surface-Active Substances [in Russian], Chernovtsy (1975), pp. 24-25.
3. Ya. V. Ganitkevich, in: The Physiological Role of Surface-Active Substances [in Russian], Chernovtsy (1975), pp. 3-5.
4. Ya. V. Ganitkevich, in: The Physiological Role of Surface-Active Substances [in Russian], Chernovtsy (1975), pp. 28-30.
5. M. E. Abrams, J. Appl. Physiol., 21, 718 (1966).
6. J. A. Clements, R. F. Hustead, R. P. Johnson, et al., J. Appl. Physiol., 16, 444 (1961).
7. J. Clements, J. Nellenbogen, and H. Trahan, Science, 169, 603 (1970).
8. J. A. Drews, D. F. Tierney, and J. R. Benfield, J. Thorac. Cardiovasc. Surg., 68, 837 (1974).
9. V. L. Kirkland, Proc. Soc. Exp. Biol. (New York), 136, 1129 (1971).