EFFECT OF INJECTION OF SYNTHETIC DETERGENT INTO THE TRACHEA AND LUNG ON BASIC PULMONARY FUNCTIONS AND SURFACE TENSION OF LUNG EXTRACTS

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UDC 612.2.014.46:348.18

Parameters of ventilation and gas exchange, expansibility, elasticity, the work of breathing in overcoming the elastic resistance of the lungs, and the surface tension of lung extracts were studied in control rabbits and in animals receiving injections of a synthetic detergent into the trachea and lung. The detergent causes considerable structural changes in the lungs, increases the surface tension of lung extracts, reduces the expansibility of the lung tissue, increases its elasticity, reduces the ventilation, and increases the work of breathing in overcoming the elastic resistance of the lungs.

Surfactants of the lungs participate in the mechanics of respiration [2, 5] and are used in the treatment of diseases in which the production of the surfactant is disturbed [3, 4]. Meanwhile the surfactants used in industry or in everyday life may have undesirable effects on the body.

The effect of a synthetic detergent was studied on the parameters of ventilation and gas exchange, the intrapleural pressure (IPP), and the surface tension of lung extracts (STLE).

EXPERIMENTAL METHOD

Experiments were carried out on 37 unanesthetized rabbits; an injection of the detergent Novost' (2% solution, 2.5 ml per rabbit) was given into the trachea of 8 and into the lung (by puncture of the chest wall) of 7 rabbits. The external respiration, IPP, and STLE were investigated in the control and experimental (24 h after injection of detergent) rabbits. The external respiration was studied spirographically at rest and after induction of a right-sided artificial pneumothorax (20 ml/kg). The IPP was recorded kymographically with the aid of a water manometer. Parameters of the mechanics of respiration – expansibility, elasticity, and work in overcoming the elastic resistance [1] – were determined. The STLE of the upper lobe of the left lung was investigated stalagmometrically.

EXPERIMENTAL RESULTS

The results are given in Table 1. In the control, pneumothorax led to an increase in the IPP, a decrease in the pulmonary ventilation, a decrease in the oxygen consumption, and an increase in the work of breathing. The normal IPP was restored after 2 h but the depth of respiration (DR) and its minute volume (MVR) remained low. The work of breathing increased. Morphologically, areas of atelectasis were found in the collapsed lung among areas of unchanged tissue.

Intratracheal injection of the detergent lowered the DR but the MVR remained unchanged because of an increase in the rate of respiration. The expansibility of the lungs was reduced. During loading by the pneumothorax the dynamics of the spirographic indices and the work of breathing were indistinguishable from the control. Unlike in the control, however, the IPP did not return to normal in 2 h. Morphologically, areas of atelectasis, emphysema, and edema were found in the lung tissue. The STLE was increased.

Department of Pathophysiology, Izhevsk Medical Institute. (Presented by Academician of the Academy of Medical Sciences of the USSR A. M. Chernukh.) Translated from Byulleten' Eksperimental'noi Biologii i Meditsiny, Vol. 77, No. 5, pp. 6-8, May, 1974. Original article submitted February 9, 1973.

TABLE 1. Parameters of External Respiration and Mechanics of Respiration, Intrapleural Pressure, and Surface Tension of Lung Extracts in Animals after Injection of Detergent into the Trachea and Lung (M±m)

Series of experiments	Depth of respiration (in ml/kg)			MVL (in ml/min/kg)			IPP (in cm water)		
	before induction of pneumothorax	immediately after induction	2 h after induction	before pneumothorax induction	immediately after induction	2 h after induction	before pneumothorax induction	immediately after induction	2 h after induction
Control	5,13±0,29	3,70±0,26	3,85±0,42	750±60	540±50	510±80	(—2,14)±0,13	(—0,49)±0,12	(—1,93)±0,20
P		<0,01	<0,01		<0,02	<0,05		<0,01	>0,05
Injection of detergent into the trachea	3,69±0,29	2,76±0,30	2,01±0,42	700±82	525±81	250±61	(—1,97)±0,43	(—0,57)±0,15	(—0,87)±0,26
P		<0,05	<0,05		>0,05	<0,05		<0,05	<0,05
P_1	<0,01		<0,01	>0,05		<0,05			
Injection of detergent into the lung	2,80±0,46	3,50±0,69	2,13±0,53	494±93	612±104	276±69	(—1,51)±0,16	(—0,13)±0,10	(—0,32)±0,14
P		>0,05	>0,05		>0,05	>0,05		<0,05	<0,05
P_1	<0,01		<0,02	<0,05		<0,05			

TABLE 1 (continued)

Series of experiments	Work of breathing (g/cm/ml)			Elasticity (g/cm/ml)	Expansibility (ml/cm)	Surface tension (dynes/cm)
	before pneumothorax induction	immediately after induction	2 h after induction			
Control	0,210±0,05	0,250±0,05	0,570±0,115	0,035±0,012	52,0±15,7	62,92±0,88
P		>0,05	<0,05			
Injection of detergent into the trachea	0,120±0,003	300±0,06	0,850±0,25	0,049±0,012	31,57±8,67	65,79±1,09
P		<0,05	<0,05			
P_1	>0,05		>0,05	>0,05	>0,05	0,05
Injection of detergent into the lung	0,310±0,08	0,320±0,11	0,690±0,20	0,120±0,05	23,10±7,08	68,09±0,48
P		>0,05	<0,05			
P_1	>0,05		>0,05	<0,05	>0,05	<0,01

Legend: P) Significance of differences between parameters before and after induction of pneumothorax; P_1) the same between control and experimental series.

After injection of the detergent into the lung the animals' breathing became superficial, MVR and the expansibility of the lungs were reduced, but the work of breathing was increased. Loading led to a temporary increase in DR and MVR followed by a decrease in the parameters of ventilation; the work of breathing was increased. The IPP was not restored to normal during the course of the experiment. Morphologically, changes of emphysema were discovered; the atelectasis became less marked than in the control. The STLE was increased.

The tests thus showed that the detergent produces changes in the lungs (edema, emphysema, atelectasis). The decrease in the content of surfactant in the lungs and in the expansibility of the lung tissue under these conditions give rise to changes in the ventilation parameters and to a compensatory increase in the work of breathing during loading.

The increase in STLE of the experimental animals was evidently connected with the decrease in endogenous surfactants in the lungs. The latter could either be the result of the harmful action of exogenous surfactants on the pulmonary epithelium or a manifestation of the feedback principle implying the participation of regulatory mechanisms.

LITERATURE CITED

1. M. Navratil, The Pathophysiology of Respiration [in Russian], Moscow (1967), p. 34.
2. J. Archie, Dis. Chest., 53, 759 (1968).
3. S. Bondurant, Clin. Res., No. 11, 234 (1963).
4. R. Robillard, Canad. Med. Ass. J., 90, 55 (1964).
5. P. Tierney, J. Appl. Physiol., 20, 1253 (1965).