BIOCHEMISTRY AND BIOPHYSICS

ABSORPTION OF RADIOACTIVE PHOSPHORUS FROM THE PLEURAL CAVITY

V. R. Faitelberg-Blank and Yu. B. Sosyura

Chair of Pathophysiology (Chief – Professor N. N. Zaiko), The N. I. Pirogov Odessa State Medical Institute (Director – Professor I. Ya. Deineka)

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There are a number of papers in the literature devoted to the question of absorption from serous cavities under various conditions.

Starling discovered the absorption of carmine and methylene blue from the pleural cavity in experiments on anesthetized dogs. Later it was found that other dyes as well as sodium chloride were readily absorbed from the pleural cavity and that this absorption was diminished when the central nervous system was excluded.

O. M. Goldina [1] observed the absorption of methylene blue from the pleural cavity in man. Studies on the absorption from the pleural cavity of various contrast media ("Sergosin" Thorotrast, barium sulphate) revealed that these substances were absorbed mainly through the parietal pleura [4]. Experiments on rabbits and mice were used for the study of penicillin absorption from the pleural cavity and showed that when the pleura was inflamed its absorption was reduced [6].

V. P. Plosky (1955) discovered that chloral hydrate and barbituric acid derivatives were well absorbed from the pleural cavity in animals. He succeeded in producing fairly prolonged narcosis in animals by intrapleural injection of narcotic substances.

The existing views on the spread of substances absorbed through the mesothelium can be summarized as follows: true solutions, once absorbed, pass predominantly into the blood capillaries and partially into lymphatic capillaries; colloidal solutions pass predominantly into the lymphatic vessels and partially into the blood vessels, while suspensions pass into the lymphatic system exclusively [3].

The mechanism of absorption from the pleural cavity is explained in various ways. While some authors explain absorption from serous cavities by physico-chemical factors (diffusion, osmosis), V. N. Orlov [5], A. A. Bogomolets (1908) and others regard it as an active biologic process regulated by the central nervous system.

The use of radioactive isotopes has made it possible to study the distribution of substances absorbed from the pleural cavity in the viscera (a study not previously feasible), using intrapleural injections of dye solutions or saline solutions.

The present work is concerned with the study of radioactive phosphorus absorption from the pleural cavity under ordinary conditions and against the background of artificial pneumothorax.

EXPERIMENTAL METHODS

Experiments were performed on 15 rabbits. Under manometric control radioactive phosphorus in the form of the sodium salt $Na_2HP^{32}O_4$ was injected into the pleural cavity in the dose of 50 million impulses per minute per 1 kg body weight. Samples of blood were then withdrawn from the pinna vein at constant intervals of time (3, 5, 10, 15, 20, 30, 45, 60, 90, 120 minutes) and their P^{32} content determined. Two hours after administration of P^{32} the animals were sacrificed (electric current) and the liver and lungs removed for P^{32} determination.

EXPERIMENTAL RESULTS

As a result of these experiments it was found that radioactive phosphorus was absorbed fairly rapidly and in appreciable amounts from the pleural cavity into the blood. Thus, 3 minutes after administration of radioactive phosphorus intrapleurally the percentage of its take up in the blood was 18.25 in rabbit No. 1, 18.75 in rabbit No. 2 and so on. The amount of radioactive phosphorus in the blood increased with time and in most experiments reached a maximum after 20-30 minutes (Table 1).

TABLE 1

Dynamics of Radioactive Phosphorus Absorption From the Pleural Cavity into the Blood

Experiment No.	Amount of phosphorus administered (imp/min/1 g tissue)	% uptake in blood after									
		3 min	5 min	10 min	15 min	20 min	30 min	45 min	60 min	90 min	120 min
Absorption under ordinary conditions											
1	5 100	18.25	33.4	41	47.3	56 9	63 1	61	83.2	90.7	108.3
2	5 112	18.75	22.9	43.75	84.75	94.39	69.7	40.75	83.5	64.25	101.1
3	5 225	—	20.45	47.9	56.5	72.1	93.5	63.73	60.0	50.75	99.1
4	5 200	18.5	44	37	54.5	59.1	86.3	100	80.4	67.5	96.4
5	5 250	23	57.2	92.5	130	144	150.2	129.1	123.1	119	124
6	4 436	42.5	35	68.5	131.6	66 5	62.1	59.5	89.5	79	73.7
7	5 254	80	79.3	80.1	90.1	91.3	84.2	105	85.5	74.1	86 7
8	5 000	80	29.4	47	89.2	71.5	58.2	101.2	97.2	100	100.3
Absorption under conditions of artificial pneumothorax											
9	4 900	14 7	34.6	45.7	69 38	62 6	134	65.7	61 8	41.25	50.4
10	5 010	24 4	36 6	45.5	61	51.1	47.1	82.5	55.5	36.7	49.5
11	5 200	16	29.9	52.7	74.25	107	133.2	—	122	129	59.2
12	5 085	21.8	33.2	48.3	68.2	69.5	121.6	74.1	71.5	52.3	46
13	5 200	18.3	38	51 8	62.2	71 6	127	68.3	50.4	32.8	49 5

M. Ya. Subbotin [7], studying absorption of dye-stuff from the abdominal cavity in rabbit, discovered that resorption occurred most vigorously during the first 30 minutes.

Investigation of the deposition of radioactive phosphorus absorbed from the pleural cavity in some of the viscera revealed that after 2 hours 1 g of liver contained such an amount of radioactive phosphorus that it gave, on the average, 10,048 imp/min with fluctuations from 5,604 to 16,056 imp/min. 1 g of left lung contained amounts of radioactive phosphorus giving the average of 7,069 imp/min with fluctuations from 2,800 to 16,880 imp/min. These data show that the radioactive phosphorus absorbed from the pleural cavity was deposited in the liver to a greater extent than in the lungs.

In the second series of experiments a study was made of radioactive phosphorus absorption from the pleural cavity in rabbit under conditions of artificial pneumothorax. The air was introduced into the right pleural cavity, under sterile conditions, thrice at 24 hour intervals by means of the Kochkachev pneumothorax apparatus.

Fifty ml of air was introduced in the first instance, 65 ml in the second and during the third administration the air was introduced until the intrapleural pressure reached slightly positive values (+ 2 cm of water).

The general condition of the rabbits after application of artificial pneumothorax was not altered appreciably. The increased rate of respiration noticed directly after the procedure returned to normal after a few minutes.

The results of these experiments demonstrated that the absorption of radioactive phosphorus from the pleural cavity into the blood in the presence of artificial pneumothorax was slowed down. Under these conditions the percentage uptake into the blood after 120 minutes was 40.5-59.2 (Table 1) as against 73.7-124 under normal conditions. It must be noted that, while the degree of absorption of radioactive phosphorus is lowered in the case of pneumothorax, its maximal accumulation in the blood takes place in the majority of cases similarly

to control animals, i. e., at the 30th minute. R. O. Faltelberg and L. B. Akselrod [8] observed slowing of neutral red absorption from the pleural cavity of dogs in the presence of artificial pneumothorax.

Deposition of radioactive phosphorus in the liver 2 hours after its introduction into the pleural cavity against the background of artificial pneumothorax occurred to a greater extent than in control animals (Table 2). It was also deposited to a greater extent in the left lung. Thus, under ordinary experimental conditions its percentage uptake in the left lung was 54-317.4 while with pneumothorax it was 368-552.5.

It must be mentioned that there is a difference between the deposition of radioactive phosphorus in the right and left lung under ordinary conditions and against the background of artificial pneumothorax. In the former case considerably more radioactive phosphorus is deposited in the right lung as compared with the left. This possibly depends on the fact that radioactive phosphorus is introduced into the right pleural cavity. In the case of artificial pneumothorax more phosphorus is deposited in the left, noncompressed, lung than in the right, compressed, lung.

When 1 g of right lung (on the side of pneumothorax) showed activity of 8,560-11,800 imp/min it reached 18,700-27,000 imp/min in the left lung (Table 2).

TABLE 2

Distribution of Radioactive Phosphorus Absorbed from the Pleural Cavity in the Viscera 2 Hours After its Introduction

Experiment No.	Hours after admin. of P	Amt. of P (imp/min/g tissue)	% blood uptake	Liver			Lungs (left)		
				no. imp/min/g liver	% uptake	activity of blood (in %)	no. imp/min/g lung	% uptake	activity of blood (in %)
Under ordinary conditions									
1	2	5 100	108	5 604	109	101	2 800	54	506
2	2	5 112	101	12 088	236	507,2	6 345	124.1	262
3	2	5 225	99.1	9 573	182	640	5 394	103	351
4	2	5 200	96.4	10 500	202	168	5 700	128 8	358
5	2	5 250	124	11 140	214	176	8 200	137	126
6	2	4 436	73.7	6 228	140	194	5 230	118	161
7	2	5 254	86.7	16 056	305	352	16 680	317.4	365
8	2	5 000	100.3	9 192	182,1	182	5 207	104.1	104
Against background of artificial pneumothorax									
9	2	4 900	50	10 400	213	417	27 000	552 5	1 100
							9 950	201	405
10	2	5 010	49.5	9 850	193	398	18 700	368	755
							11 800	236	480
11	2	5 200	59.2	16 000	306	525	21 000	403 8	688
							10 850	210	354
12	2	5 086	46	12 400	243,8	497	23 100	456	875
							8 560	167.5	322
13	2	5 250	40.5	11 650	221	394	20 400	388	685
							11 500	219	376

Note. In the column labelled "Lungs" in the section "Against background of artificial pneumothorax" the numerator values refer to data on the left lung, the denominators to data on the right lung.

No experimental data are available at present for the explanation of this phenomenon. It may be that the smaller deposition of radioactive phosphorus in the compressed lung is determined by impaired circulation in it. A big role is doubtless played also by neuro-reflex influences arising from pleural receptors in the course of artificial pneumothorax application. These questions are to be the subject of further investigations by the present authors.

The following conclusions can be drawn on the basis of the present experiments.

Radioactive phosphorus is rapidly absorbed from the pleural cavity: it is detected in the blood in appreciable quantities as early as 3 minutes following its introduction into the pleural cavity. Its accumulation reaches a maximum after 20-30 minutes, followed by a gradual decline; in a number of cases a second maximum is seen after 120 minutes.

The radioactive phosphorus absorbed from the pleural cavity is deposited in the viscera. As soon as 2 hours later radioactive phosphorus is found in considerable amounts in the liver and lung, its content in the former being higher than in the latter (left).

Radioactive phosphorus absorption from the pleural cavity proceeds less vigorously under conditions of artificial pneumothorax. It is first detected in the blood after 3 minutes and reaches a maximum at the 20th-30th minute, as in the case of ordinary conditions; after 2 hours the amount of radioactive phosphorus absorbed into the blood is considerably less than under ordinary conditions.

Radioactive phosphorus absorbed from the pleural cavity in the presence of artificial pneumothorax is deposited in the liver and lungs to a greater extent than under ordinary conditions.

More radioactive phosphorus is deposited in the left, uncompressed, lung as compared with the right one which is compressed by the air.

SUMMARY

Absorption of radioactive phosphorus from the pleural cavity was studied under normal conditions and against the background of artificial pneumothorax. Radioactive phosphorus in the form of a sodium salt was injected at the rate of 50 million impulses per minute per kg of body weight into the pleural cavity under manometric control. Deposition of radioactive phosphorus in the blood and in internal organs (liver, lungs) was determined. Three minutes after the injection radioactive phosphorus was evident in the blood, the maximum concentration being reached in 20-30 minutes. Two hours later, considerable portions of radioactive phosphorus were evident in the liver and lungs.

Artificial pneumothorax lowered absorption of radioactive phosphorus, but raised its deposition in the liver and lungs. Deposition of radioactive phosphorus in the left normal lung was higher than in the right collapsed one.

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