THE PATHOGENESIS OF PULMONARY EDEMA CAUSED BY SILVER NITRATE

COMMUNICATION II. CIRCULATORY DISTRUBANCES AND PULMONARY EDEMA

B. I. Mazhbich

From the Departmant of Pathological Physiology (Head – Professor Ya. A. Lazaris) Karagandinskii State Medical Institute (Direcctor – Docent P. M. Pospelov)

(Received October 23, 1958. Presented by Active Member of the AMN SSSR V. N. Chernigovskii)

The problem of the significance of circulatory disturbances in pulmonary edema is an old one, but it still awaits solution. The edema is often associated with circulatory disturbances but this fact by itself does not explain the causal relationships.

It has been shown that for many clinical and experimental forms of pulmonary edema, the circulatory disturbances constitute the principal symptom [1, 4, 5, 6, 7, 10, 11, 12]. In other cases such disturbances develop only in the terminal stages of the illness, and appear to be secondary to the edema [2, 8, 9].

In the present study, to determine the relationships between the two conditions, we made use of pulmonary edema induced by silver nitrate.

After injecting this substance, in addition to the edema, severe circulatory disorders develop [3].

METHOD

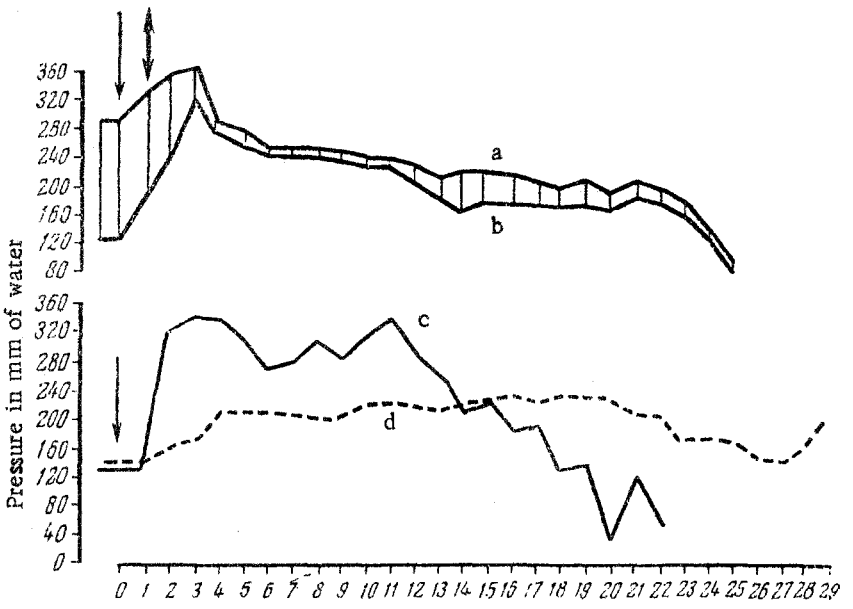
Ten adult dogs were used in the experiments. As a control, 27 animals were used, their treatment being as described in the Tables under the headings "Control No. 1" and "Control No. 2".

One group of 5 animals received the silver nitrate by inhaling it in the form of an aerosol. For this purpose a glass atomizer was filled with a 4% solution of silver nitrate. A bent glass cannula was connected to a diaphragm pump, and inseted into a slit in the trachea, the diameter, length, and angle at the bend chosen so that for the particular pumping rate and atomizer aperture, an appropriate atomizing speed and particle diameter were obtained.

To eliminate any possible effect due to osmosis, in one experiment, 4% Na Cl solution was substituted for the 4% $AgNO_3$.

In another group of 5 dogs, 3.2 mg/kg of 0.4% silver nitrate solution was injected intravenously.

To maintain the pressure in the pulmonary artery near to its original level, the chlorvinyl catheter into the pulmonary artery to measure the pressure was also connected to a vertical glass tube whose height could be adjected. The whole system was filled with physiological saline. The side opening in the tube was placed at a level such that blood entering the tube from the catheter could not escape through it. As soon as the pressure in the pulmonary artery was raised after injecting the silver nitrate, the system was closed, and blood from the side hole in the tube flowed out into a special receiving funnel, and thence into the venous system of the greater circulation.



Pressure in the pulmonary artery under different experimental conditions (average figures). Curves, from above downwards: a) systolic and b) diastolic pressure in the pulmonary artery in an experiment in which the increase in pressure is eliminated artificially; c) mean systolic and diastolic pressure in the pulmonary artery following intravenous injection of silver nitrate only; d) mean systolic and diastolic pressure in the pulmonary artery when silver nitrate is inhaled. The abscissa shows average survival time of the animals in minutes after injecting silver nitrate (moment of injection shown by arrow ↓), the double arrow indicates the moment at which the mechanism for preventing blood pressure increase is put into action.

Ratio of Weight of Body, Heart, and Dried Lung Residue to Fresh Lung Weight

Series	Number of expts.	Ratio of lung wt. (in g) to body wt. (M ± m)	Ratio of lung wt. (in g) to heart wt. (M ± m)	Dried lung residue as percentage of fresh weight
Silver nitrate inhaled	5	23.00 ± 2.82	2.70 ± 0.31	13.40 ± 0.84
Blood pressure in pulmonary artery maintained at approximately original level	5	25.30 ± 2.30	3.12 ± 0.37	15.35 ± 0.79
Control No. 1				
Silver nitrate injected intravenously, no other operation	20	38.55 ± 1.60	4.68 ± 0.25	13.40 ± 0.35
Control No. 2				
Intact animals, killed by electrification	7	9.35 ± 0.83	0.96 ± 0.05	20.10 ± 0.41

Heparin was added, and the surface of the apparatus in contact with the blood was covered with silicone.

RESULTS

The table and figure show changes in the relative weights of the lungs and in the pressure of the pulmonary artery. From the figure (d), it can be seen that for pulmonary edema to develop, it is not necessary for the pressure in the pulmonary artery to be increased.

In the inhalation experiment, in spite of the fact that there was no significant increase in the pressure in this artery, the degree of edema as measured in terms of the dry lung tissue was the same as that in Control No. 1 (see Table). The smaller ratio of lung weight to body and heart weight than in Control No. 1 indicates that the lungs of the animals in this series contained considerably less blood.

In the experiments where increase in pulmonary artery pressure was eliminated, edema developed just the same. This can be seen by comparing the results for the lungs of the animals in this series, with those of normal animals (Control No. 2).

In these experiments, the pressure in the pulmonary artery was less than the initial systolic pressure, except for the small initial increase, which may be partly ascribed to the failure to operate the pressure levelling mechanism at precisely the amount at which the silver nitrate was injected (see figure).

The ratio of lung weight to body and heart weight, and the ratio of the dried lung residue to the raw weight, as found in the experiment in which an isosmotic solution of sodium chloride was injected, showed that the values obtained do not differ appreciably from the normal values (Control No. 2).

Both we and A. M. Kotovshchikov [3] have shown that pulmonary edema induced by silver nitrate may occur without any increase in pulmonary artery pressure and without any appreciable circulatory disorders developing.

We have shown previously that after a silver nitrate injection there is no increase in the pressure in the pulmonary vein, but that on the contrary, it was reduced. Since this reduction in pressure could not be a pathogenic factor in pulmonary edema, it has not been recorded in the present experiments.

Neither we nor A. M. Kotovshchikov [3] were able to reproduced the previously mentioned experiments in which there were no circulatory disturbances in the pulmonary circulation For this purpose, certain special conditions are required which it is not possible to determine precisely.

It must be supposed that one such condition is a partial failure of cardiac muscle. It may be associated with severe operational trauma, or with the effect of the anesthetic, or with any other factor which will interfere with the action of the heart before the injection of the silver nitrate.

When giving the silver nitrate by inhalation, it was not possible to induce pulmonary edema without any disturbance to the lesser circulation, but the increase in pressure in the pulmonary artery when using this method was very much less than when the silver nitrate was injected intravenously(see figure).

The extent of the pulmonary edema as determined from the dry pulmonary tissue residue did not differ from that produced by intravenous injection. The smaller ratio of lung weight to body and heart weight in the experiments in which the preparation was inhaled, is evidently not due so much to the accumulation of transudate, as to the different degree of engorgement of the lungs with blood.

In the other set of experiments, in which pressure changes in the pulmonary artery were artificially excluded, it was shown that the development of the condition does not depend upon this pressure increase. The slightly smaller degree of edema in this case is understandable, because with this method, inevitably a smaller amount of blood passes through the lungs in unit time. It has long been known that a reduction in blood flow to the lungs during the development of edema will reduce the amount of transudate.

Probably the increased pressure in the pulmonary artery does not represent the principal factor causing the edema. We have shown previously that the observed circulatory disturbances cannot be caused by the edema of the lungs.

The edema and the circulatory disturbances are two separate consequences of the silver nitrate injection. Both processes also react upon each other, as can be seen from the results which have been presented.

SUMMARY

The effect of circulatory disturbances on pulmonary edema caused by silver nitrate injections in dogs was studied. Silver nitrate was inhaled or injected, and arrangements were made for artificially preventing an increase in pressure in the pulmonary artery when required; it was shown that circulatory disturbance is not an important factor in pulmonary edema.

LITERATURE CITED

[1] F. Aleksandrov, The Origin of Congestive Pulmonary Edema.* Dissertation. Moscow, 1892.

[2] R. A. Dymshits, Manual of Pathological Physiology,* 1936, volume 3, pp.276-296.

[3] A. M. Kotovshchikov, The Problem of Alterations in Cardiac Activity and Circulation in Acute Pulmonary Edema.* Dissertation for Doctorate (Moscow, 1911).

[4] N. A. Kurshakov, Ter. arkh., No. 5, pp.122-123 (1939).

[5] S. I. Umanskii, Klin. med., No. 2, pp.194-203 (1937).

[6] A. B. Fokht, Edema and Dropsy.* Moscow, 1919.

[7] M. D. Altschule, Acute Pulmonary Edema (New York, 1954).

[8] D. Halmagyi, B. Felkay, J. Ivanyi, et al., Kiserl Orvostud. 7, 563-568 (1955).

[9] E. Laquer, R. Magnus, Ztschr. ges. exper. Med. 13, 31-290 (1921).

[10] A. A. Luisada, L. Cardi, Circulation, 1956, v.13, p.113-135.

[11] M. B. Visscher F. J. Haddy, and G. Stephens, Pharmacol. Rev., 1956, v.8, p.389-434.

[12] W. H. Welch, Arch. path. Anat., 72, 375-412 (1878).

*In Russian.