13383

Effect of Propylene Glycol Aerosol on Air-Borne Virus of Influenza A.

WERNER HENLE AND JOSEPH ZELLAT. (Introduced by Stuart Mudd.)

From the Department of Pediatrics, School of Medicine, University of Pennsylvania, and the Children's Hospital of Philadelphia, Pennsylvania.

The recovery of the virus of influenza A from artificially infected air[1] showed that air-borne transmission of this agent is possible. Exposure of ferrets to infected air proved that the virus can be transmitted by this route.[2, 3] The development of a new technic for the study of experimental air-borne infection[4] permitted the exposure of ferrets and mice to the infected air on a quantitative basis and typical disease followed the inhalation of the air-borne influenza virus.[5] It was found that ultraviolet irradiation of the infected air destroyed the virus[1] and disease did not develop in animals exposed to air-borne virus thus treated.[5]

Sterilization of air by aerosols has been attempted, using various bacteria and fungi as test organisms[6-9] but only a preliminary statement regarding their effect on viruses has been published.[9] In a recent study Robertson and his coworkers[10] demonstrated the successful application of glycols as aerosols to the destruction of bacteria suspended in air as shown by plating methods. The present paper adds the virus of influenza A to the group of infectious agents attacked by propylene glycol aerosols. The direct animal test, *i. e.*, the exposure of mice to the infected air treated with this reagent was the experimental method used.

Briefly the technic employed was as follows: One atomizer flask[4] contained the virus suspension, another either propylene glycol or

1 Wells, W. F., and Brown, H. W., *Science*, 1936, **84**, 68; *Am. J. Hyg.*, 1936, **24**, 407.

2 Trillat, A., and Beauvillain, E., *Compt. rend. Acad. d. Sci.*, 1937, **205**, 1186; *Rev. d'Hyg.*, 1938, **60**, 104.

3 Andrewes, C. H., and Glover, R. E., *Brit. J. Exp. Path.*, 1941, **22**, 91.

4 Wells, W. F., *Science*, 1940, **91**, 172.

5 Wells, W. F., and Henle, W., PROC. SOC. EXP. BIOL. AND MED., 1941, **48**, 298.

6 Trillat, A., *Bull. de l'Acad. de Med.*, 3 Serie, 1938, **119**, 64.

7 Pulvertaft, R. S. V., and Walker, J. W., *J. Hyg.*, 1939, **39**, 696.

8 Twort, C. C., Baker, A. H., Finn, S. R., and Powell, E. O., *J. Hyg.*, 1940, **40**, 253.

9 Andrewes, C. H., *Lancet*, 1940, **2**, 770.

10 Robertson, O. H., Bigg, E., Miller, B. F., and Baker, Z., *Science*, 1941, **93**, 213.

water as control. The air-streams from both of the atomizer flasks carrying the atomized materials were mixed in a 5 liter bottle and the mixture was introduced into the infection chamber.[4] The air was forced through the system instead of being aspirated by an incinerating chimney. With 0.2 to 0.3 cubic foot of air passing through the apparatus per minute a complete turnover of the air was accomplished in 1½ to 2 minutes.

The extra-embryonic fluids of the chick infected with influenza A[11] served as virus suspension. In some experiments fluids previously kept at –72°C were used and repetition produced closely similar results. Only the F-12 strain[12] was employed in this study. White mice were exposed for 45 minutes to the infected air and the lesions following the inhalation of the air-borne influenza virus in this set-up resembled those described elsewhere.[5]

The effect of an aerosol of propylene glycol on influenza virus suspended in air is demonstrated in Table I. Serial decimal dilutions of the virus were atomized, and the infected air was mixed either with the propylene glycol aerosol or with atomized water as control. The concentration of either agent in the air was approximately 1 part in 200,000, as determined by the loss of weight from the atomizer flasks during the experiment. The control group exposed to the atomized 10^{-3} dilution of the virus showed lesions in more than 50% of the mice, while no lesions were observed in the experimental animals when a 10^{-2} dilution of the virus was atomized in the presence of propylene glycol. A reduction in active virus of 90 to 99% was therefore indicated by these results. One reaches a similar conclusion by comparing the death rate in the 2 groups of mice. While in the control group the atomized 10^{-1} dilution of virus produced death in nearly 50% of the animals, only one mouse in the experimental group died following inhalation of the highest concentration of virus. In other experiments a concentration of propylene glycol in air of 1 part in 1 million still proved effective in reducing the air-borne virus. Using a very strong virus preparation the only effect of the propylene glycol aerosol noticeable was a prolongation of the time of survival. No attempt was made to reduce the turnover of air which was accomplished every 1½ to 2 minutes, to allow for a more extensive interaction between the air-borne virus and the aerosol.

Propylene glycol neutralized the virus when added to it in equal

[11] Henle, W., and Chambers, L. A., PROC. SOC. EXP. BIOL. AND MED., 1941, **46**, 713.

[12] Stokes, J., Jr., and Wolman, I. J., *New International Clinics*, 1940, **1**, 115.

TABLE I.

Effect of Propylene Glycol Aerosol upon Air-borne Influenza Virus.

Flask 1 Aerosol	Flask 2 Dilution of virus	Air-borne inoculation — Influenzal lesions in mice					Intranasal inoculation of wash fluid — Influenzal lesions in mice			
Propyl. glycol	undil.	D11	3	2	2	1	0	0	0	0
		1	1	0	0	0				
	10-1	2	2	2	1	1	0	0	0	0
		1	1	0	0	0				
	10-2	0	0	0	0	0	0	0	0	0
		0	0	0	0	0*				
Water	undil.	D6	D6	D6	D8	D8	D5	D8	D8	2
		D8	D9	D9	D9	D11				
	10-1	D9	D9	D9	D11	4	D7	D9	D10	3
		3	3	3	3	2				
	10-2	3	2	2	2	2	2	1	1	0
		2	1	1	1	1				
	10-3	2	2	1	1	1	0	0	0	0
		1	0	0	0	0				
	10-4	0	0	0	0	0	0	0	0	0
		0	0	0	0	0				

D5 = died on the fifth day.
4 = lung totally consolidated when autopsied on 11th day.
3 = ¾, 2 = ½, 1 = ¼ of the lung consolidated.
* = atypical death with no lung lesion.

proportions. This was shown by intranasal instillation of the mixture into slightly anesthetized mice. While undiluted propylene glycol neutralized one million MLD of virus or possibly more, a 10% solution was without effect. Under the conditions of the experiment, however, the virus came into contact with the undiluted propylene glycol as an aerosol[10] or vapor, which therefore proved effective.* When the mixing bottle was washed with 2 or 3 ml of broth to collect traces of fluid precipitated during the experiment, this wash fluid was not infective when tested in mice by the intranasal route, unless the dosage of virus used in the experiment was overwhelmingly large. The wash fluid from the control experiments produced typical lesions in the 3 most concentrated dilutions atomized (Table I). Inhalation of a propylene glycol aerosol prior to an intranasal instillation of 10 MLD of virus did not protect the experimental animals.

From these experiments it can be concluded that propylene glycol aerosol reduces the chance of air-borne infection with the virus of influenza A and may be effective in preventing air-borne spread of

* Dr. Robertson (personal communication) suggested that the propylene glycol aerosol acts by means of liberation of vapor from the droplets.

the disease. The practicability of its use for this purpose has to be investigated.

We are indebted to Dr. O. H. Robertson for reading and criticising this manuscript. Experiments conducted in Dr. Robertson's laboratory also led to the conclusion that propylene glycol is effective in combatting the air-borne influenza virus.[13]

[13] Robertson, O. H., Read before Section N, A. A. A. S., Chicago, September 23, 1941, to be published under the auspices of the A. A. A. S. as a symposium-monograph.